

GOVERNMENT OF INDIA
DEPARTMENT OF FOOD



NOTE ON FOOD AND
NUTRITION POLICY IN
INDIA

By W. R. Aykroyd, C.B.E., M.D., Sc.D.

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By W. R. Aykroyd

During the last two to three years the problem of food supply in India has been an urgent one, and the main preoccupation of Central and Provincial administrations. Cereals form the great bulk of Indian diets, providing 80—90 per cent. of total calories. Owing to a variety of circumstances there have been general and local shortages of cereals, notably rice, involving danger of starvation since in the greater part of the country there are no alternative foods available in sufficient quantities to replace cereals. By slow and painful degrees the situation as regards cereals has been brought under control, not without catastrophe in the process. Problems of procurement and distribution are being mastered and rationing has secured at least a minimum of cereals to a considerable section of the population. Active food and rationing Departments are now functioning at the Centre and in the Provinces.

A new position has thus been reached with regard to the problem of nutrition in India. It has come into the foreground of public attention, and governments are ready, as never before, to take action in this field. Experience has shown that it is possible to exercise a considerable degree of control over the diet of the people. It is generally realised that defective nutrition is a major cause of ill-health in India and that improvement in diet would lead to far-reaching changes in health and physique. Considerable interest is being taken in the question of increasing supplies of "protective" foods which are needed to provide the nutrients in which rice and other cereals are deficient. It is natural that we should ask ourselves whether the existing food organisation can be used, not only to distribute equitably foodgrains in short supply, but to raise standards of nutrition.

(2) LIMITATIONS

The food administration in Great Britain has been one of the most successful of war organisations. As a result of its various activities, the diet of the population has not deteriorated in nutritive value during the war, and may have improved. The health of the nation has not suffered. But the success achieved in England should not blind us to the fact that conditions in India are very different. In England reasonable quantities of protective foods could be produced or imported even in war time and it was the task of the food administration to distribute supplies and to teach the public how to make use of them in the wisest possible manner. It has at its disposal modern methods of education and propaganda, and has been working with an educated population ready to listen, and respond to guidance.

In India adequate supplies of protective foods are not available. This is, if anything, an understatement. For example, in various parts of the country milk and milk products are for practical pur-

poses not obtainable at all. Apart from actual shortage of protective foods, the economic factor is of primary importance. A well-balanced diet containing sufficiency of protective foods costs more than an ill-balanced diet based largely on cereals. It can be clearly shown that the bulk of the population cannot afford a well-balanced diet and lives perforce on a diet composed of the cheapest foods. This problem has been discussed and analysed in an article by myself entitled "The Economic Aspects of the Problem of Nutrition in India" published in the Indian Journal of Social Work in 1941. Before the war an ill-balanced diet of adequate calorie value consisting largely of cereals cost about Rs. 2-8-0 per adult man per month. A well-balanced diet of the same calorie value containing milk, meat, fish, vegetables, etc., in sufficient amounts cost from Rs. 5 to Rs. 6 per adult man per month. It was shown, by reference to income levels in India, that the poorer classes in general could not possibly afford a well-balanced diet. At the present time the gulf between the existing and desirable expenditure on food is wider.

Mere propagan-da in support of a greater consumption of protective foods thus lays itself open to the retort, "First provide the foods and the money to buy them, and we will eat them". Take milk for example. Everybody in India realises the value of milk; it is a part of the tradition of the country. There is no need for "Drink More Milk" campaigns to popularise milk. Milk is in fact a rare and precious fluid which everybody tries to obtain if he can—witness the precautions which have to be taken in well-to-do households to prevent its disappearance. The extreme adulteration of milk is a product of its shortage. The effect of adulteration is to spread limited supplies over a large number of consumers, for most of whom the choice is watery milk or no milk at all.

Hence the campaign to raise the intake of protective foods must be accompanied by most vigorous efforts to increase production. Simultaneously purchasing power must be raised by the general development of the resources of the country. Propaganda urging a greater consumption of various articles of diet may do something to create supply, but not very much under existing circumstances. For example, people might be encouraged by propaganda to eat more fish, and this would no doubt provide some stimulus to the fish industry. But to produce adequate supplies of fish, the industry must be completely reorganised, placed on a modern and efficient basis, and new systems of transport and distribution created.

(3) PRACTICAL MEASURES

Food production is the concern of the departments of agriculture, animal husbandry and fisheries. Something of a revolution has taken place in the mental attitude of those responsible for food production policy. Previously the policy of agricultural departments, in so far as they had any policy, was mainly directed to increasing the output of certain cash crops such as cotton and sugar-cane. Efforts were of course made to increase production of certain staple food crops, but these were not related to estimates of the nutritional requirements

of the country. To-day, as the result of the stimulus given by the Hot Springs Conference, and, it may be added, because of steady and persistent pressure on the part of nutrition workers in India, the agricultural authorities have become "nutrition-minded". They have realised the need for planned production based on a scientific assessment of nutritional needs. No doubt it will take many years for such plans to bear fruit, but at least a beginning is being made in the right direction. It is realised that distribution is almost as important as production, and the responsibilities of food administrations lie mainly in the former field. Obviously it is necessary that the activities of the food and agricultural departments should be closely correlated, both having the common aim of raising standards of nutrition. Nutrition is the main link between them.

At present, as has been pointed out, adequate supplies of protective foods are not available. What, in the circumstances, can be done immediately? The Nutrition Advisory Committee of the Indian Research Fund Association in various reports, notably its report of March 1944 on "Nutrition in India", has suggested a number of possible measures. Nutrition work in India has developed in relation to medicine and public health, and in the report in question the emphasis is somewhat on the nutritional functions of health departments. The creation of nutrition sections in Central and Provincial public health departments is recommended, and it is visualised that these should be principle guiding agents in formulating nutritional policy and devising practical measures. Stress is placed on the eradication of deficiency diseases, the nutrition of expectant and nursing mothers and infants, school-feeding, institutional feeding, the feeding of employees and labour groups, community feeding, and catering and nutrition. The need for improving dietary arrangements in hospitals is pointed out. The question of education and propaganda receives due attention. The report also deals briefly with synthetic vitamins, vitamin concentrates, processed foods and food standards and food control.

As regards short-term policy certain questions are given prominence. Among these are the need for close contact between nutrition workers and food departments, the immediate establishment of nutrition sections in public health departments, school-feeding, education, the improvement of agricultural statistics, vegetable production, the development of fisheries, the extension of rationing to cover foods other than cereals and the provision of milk to expectant and nursing mothers. Some of these activities fall within the range of food departments.

(a) **Education and propaganda.**—It has already been pointed out that the possibilities of increasing the intake of protective foods by educational methods alone are at present limited. In spite of this, however, something can be achieved by a well-considered educational campaign which avoids the error of urging people to eat what is not available and what they cannot afford. The population must by degrees be made "nutrition-conscious" in order to pave the way for future developments. A problem of major importance at the present time is the consumption of alternative cereals in place of rice. Here

the question of short supply does not arise, since it is rice that is lacking in sufficient quantities while alternative cereals are more readily obtainable. From the standpoint of nutrition the partial substitution of rice by other cereals such as wheat or millet is to be recommended. On this point food and nutrition policies are in conformity. It must be emphasised that more is needed than verbal and visual propaganda. The people must be taught to turn to alternative grains by demonstration. Suitable recipes must be devised and popularised by sale in canteens, Government restaurants, etc. The methods of preparation which are advocated must be physically possible, or, if not, steps must be taken to make them physically possible. Before undertaking an educational campaign, the cooking habits of the people and facilities for adopting unfamiliar methods of cooking (utensils, etc.), must be investigated. Thus in Bengal, one of the difficulties with regard to the popularisation of wheat is that chakkis are not generally available, so that most wheat has to be distributed as atta which readily goes bad. In Bombay, wheat can be distributed as such and ground locally in chakkis. With regard to the popularisation of wheat it would be valuable to study the story of attempts to extend its use in Ceylon. It appears that after numerous efforts to encourage the consumption of wheat in the form of whole wheat, atta, etc., the Government of Ceylon has been ultimately forced to adopt the policy of providing wheat in the form of bread. Whether this would be possible or desirable in certain parts of India is a matter for investigation.

As regards millets, similar difficulties arise as in the case of wheat, and there is the further difficulty that millets are "socially inferior" grains. In this instance some change in attitude might be brought about by well-considered propaganda. The organisation required to encourage the use of alternative grains needs careful consideration. Those concerned in the campaign must be very fully informed about the domestic habits and prejudices of the people. They must know a good deal about cooking and household facilities for cooking. There is little doubt that for this sort of work women are particularly suitable. The women of India have not yet been enlisted in the campaign for improved nutrition. It is to be regretted that up to the present domestic science institutions in India have not been to any extent concerned with problems of food, catering and nutrition. The question whether, after suitable reorganisation, such institutions could be used in the campaign for better nutrition should be investigated.

(b) **School-feeding.**—The value of this measure is generally recognised. Ideally the food or meals provided in schools should be such as to make up qualitative defects in the home diet. No food can do this more effectively than milk. We must, however, dismiss for the moment the possibility of providing milk in schools on a reasonable scale. As things are, however, almost any meal which provides additional calories is of value since in general poor children are underfed. Many get only a scanty breakfast and often no food throughout the day until the evening.

No uniform method of school feeding to suit all parts of the country can be devised. Schemes must be based on local supplies and require-

ments and organised with the co-operation and advice of nutrition workers. The main obstacle to school feeding is its cost. If all poor school children in a given area are given a meal costing 1-2 annas daily, the expenditure on school may be more than doubled. Governments in the initial stages are likely to be staggered by the cost of school feeding, but it must be realised by the authorities concerned that money spent on school feeding is money spent on "nation building" and in the long run will give large returns. School feeding need not, of course, be universal. It may be confined to schools in which the children are particularly poor and mal-nourished, or to specially mal-nourished children in certain schools. Parents who can afford it may be persuaded to contribute to the cost. At the moment what is required is that the governments concerned should take up the question and work out suitable schemes. A strong push on the part of the Central Food Department would be useful. An officer concerned with school feeding might be appointed, whose task would be to investigate the matter and make concrete suggestions. He could begin by studying the existing schemes in Cochin and Ceylon.

Apart from the question of finance, the organisation of school-feeding is by no means a simple matter. Supplies of the necessary foods have to be obtained and distributed. Arrangements for cooking have to be made. The further question arises as to responsibility for organisation and management. In England school-feeding is the concern of the educational authorities. Would educational departments in India have the necessary resources to undertake the task? School-teachers are poorly paid and difficulties might arise if they were given authority to purchase and provide food to their pupils. Should local committees be created to administer and supervise school-feeding schemes? The health authorities must be associated with such schemes and the part which they can play needs examination. Another possibility for consideration is whether local people could be persuaded to contribute to school-feeding by gifts of food. Again, school-feeding could be combined with a drive to establish vegetable gardens in school compounds which would provide additional food for the midday meal. The problem is in fact a complicated one which demands the most careful and detailed study. In the first instance it would probably have to be approached by trial and error. But given the will (and the money) there is no reason why the preliminary difficulties should not be overcome. Two years ago the rationing of large urban populations in India seemed to many an impossible task, but to-day, as a result of the most praiseworthy efforts on the part of food departments, rationing schemes are working fairly smoothly. Similar success could unquestionably be achieved in the organisation of school-feeding.

Before the war, dried skimmed milk from Australia and New Zealand was used quite widely in supplementing the diet of children in institutions. In 1938, at the instance of nutrition workers, the import duty on such milk was reduced from 30 to 10 per cent. It was in general cheaper than fresh milk locally produced, and feeding experiments showed that it produced excellent results on the health and physique of children. Dried skimmed milk is now for practical purposes unobtainable, but after the war it will come on the market again.

Since the milk supplies of India are inadequate there would be justification for encouraging the import of this valuable bye-product of the Australian and New Zealand butter industry. It could, if available at cheap cost, be used in school-feeding.

(c) **The provision of milk to expectant and nursing mothers and infants.**—Bombay has already initiated a scheme for supplying milk cheaply to these "vulnerable" groups. The extension of such schemes to other places in India is desirable. As a preliminary it may be necessary to discover whether the supply position in other centres would allow for the provision of cheap milk to the groups in question. Probably it would be necessary, in many instances, to develop and reorganise local milk supplies. The extension of milk rationing would in fact be a big problem requiring careful study. Here again the Central Food Department could provide the initiative.

(d) **Canteen-feeding.**—The N.A.C. points out that the extension of industrial canteens, etc., is eminently desirable from the standpoint of nutrition and in conformity with existing food and rationing policy, since it facilitates food distribution and helps to satisfy the special needs of manual workers. Canteens could also be used for educational purposes, *e.g.*, in the popularisation of unfamiliar foods. In England the provision of meals to industrial workers during the war has been a most successful measure and has helped to safeguard the health of workers and maintain their output and efficiency at a high level. It is hoped to continue industrial canteen feeding after the war. In India little progress has so far been made, except in certain centres, and there is no doubt that at present the idea does not appeal to many industrialists. The reasons for and against require careful examination. It is possible that once initial difficulties, inertia and conservatism were overcome, canteen feeding would become highly popular among industrial workers and would benefit employers because of its effect on the health and efficiency of their employees.

(e) **Pulses.**—Pulses are an important food in India since they add protein to cereal diet and are fairly rich in certain vitamins. The supply of pulses in various areas appears to be at the moment unsatisfactory. The Famine Inquiry Commission, during its tours, found some difficulty in grasping the position as regards pulses; in some areas there seemed to be a glut and in others a shortage, and demand and supply appeared to be uncorrelated. An improvement in distribution would be a step towards better nutrition. Existing difficulties seem to be partly due to lack of knowledge of local preferences for different kinds of pulses. These are important, since local methods of cooking are often based on the use of certain familiar pulses and people may be as reluctant to change their favourite pulse as their staple cereal. There is also some lack of knowledge about the supply and distribution of pulses in normal times. The whole situation needs clarifying and this can only be done by a special investigation based on the collection of information from the various provinces.

(f) **Vegetables and fish.**—Complaints about the shortage and high prices of vegetables are numerous. Military demand is of importance in certain areas, and steps have already been taken to increase pro-

duction to meet this demand. The stimulus thus provided to production should prove of value after the war when areas now growing vegetables for the military can be used to supply civilian needs. Steps should be taken in due course to utilise military production arrangements to meet civilian needs, the present level of production being maintained and extended.

In Bombay some vegetables are sold cheaply in the Government ration shops. This might be possible in other parts of the country. There is a great need to extend production in the neighbourhood of cities. Vegetables in general can be fairly easily grown, and in this case demand can do something to increase supply. A cautious "Eat More Vegetables" campaign would, therefore, be probably justified, but the primary emphasis is on increased production.

With regard to fish, this food is available in abundance in the sea but largely remains in the sea. The development of the fishing industry appears to offer the most feasible and immediate prospect of supplementing Indian diets in respect of protein and certain other nutrients. Strong emphasis should, therefore, be placed on fish in connection with food policy. The question of distribution is of course of the greatest importance. In Bengal lack of ice or other forms of refrigeration appears to be one of the main obstacles to increasing its supply. It may take years to increase milk production and it is difficult to visualise meat and eggs becoming a staple article of diet for the Indian masses, but an abundant supply of fish could probably be made available within a few years if a strenuous effort was made to develop the industry on modern lines.

(4) CONSUMER RESEARCH

The policy of food departments must be based on correct and adequate information. At present food administrations generally appear to be somewhat in the dark about the effect of rationing on dietary habits. No satisfactory explanation is forthcoming of the low offtake of cereal rations in certain centres. It is not clear whether it is due to inability to afford the ration, to the fact that the ration is excessive, to sufficiency of unrationed foods, etc. In connection with protective foods, universal complaints are made that their consumption on the part of the middle classes has been reduced by high prices, but here again no exact information is available. Every food department should have a section devoted to research on such matters so that a change in policy would not be a leap in the dark but a considered move based on adequate study and data.

More information about dietary habits in general is also needed in connection with the planning of food production. This at present concerns agricultural authorities rather than food departments. The Nutrition Advisory Committee has recommended that the problem of devising ways and means of carrying out diet surveys in different parts of the country should be taken up by the E., H. and L. Department.

(5) EXISTING ORGANISATION IN THE FIELD OF NUTRITION

For the development of nutrition work in India in association with medical, health, food and other departments it is necessary to have

sufficient personnel, suitable institutions, etc. The following is a brief account of the present position in India:

(a) **The Nutrition Advisory Committee of the Indian Research Fund Association** was established in 1936. In early days its main function was to advise the Scientific Advisory Board of the I. R. F. A. about enquiries relating to nutrition, and select those worthy of financial support. The I. R. F. A. finances research on various aspects of nutrition in University laboratories, research institutions, etc., in various parts of the country. During recent years the N. A. C. has developed into an advisory body concerned with broader aspects of nutrition, meeting several times in a year. It has produced reports on nutrition policy and on various other aspects of nutrition such as methods of carrying out dietary surveys, a programme of future nutrition research and nutrition policy in India generally. Its reports are circulated to Provincial governments. Nutritional problems arising in the Food Department could certainly be submitted to the N. A. C. for opinion, but it is not a body in permanent being and hence could only advise from time to time. The N. A. C. includes experts in other fields beside nutrition. It has among its members the Agricultural Commissioner with the Government of India, the Animal Husbandry Commissioner and the Rationing Adviser.

(b) **Nutrition Research Laboratories, Coonoor.**—The Nutrition Research Laboratories are primarily a research organisation. Attention has, however, been given to education and propaganda on nutrition and diet. Three popular health bulletins entitled "The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets" (No. 23), "Rice" (No. 28) and "Food and Diet (written for children)" (No. 30) have been published in the Government of India Health Bulletin Series. Health Bulletin No. 23 has run into its third edition and attained wide popularity. Numerous scientific papers are published from the Laboratories, mainly in the Indian Journal of Medical Research. These are of a strictly technical nature and of no use for propaganda purposes. Lectures and broadcasts are given from time to time. Before the present pressure on newspaper space, press notes were issued when suitable materials were available.

A nutrition class lasting about 8 weeks is given annually in the Laboratories during the months of April to June. Classes are attended by Provincial health officers and various other kinds of workers. There is a museum in the Laboratories which is visited by numerous members of the public. Some of the material in the museum could be reproduced for educational purposes in India generally.

The last nutrition class (1944) included a doctor who has since organised a Nutrition Section in the War Services Exhibition. This exhibition includes a restaurant which supplies cheap and nutritious foods, and a series of exhibits on food and nutrition to further the interest of consumers in the subject of food.

(c) **Other nutrition research.**—The Indian Research Fund Association finances nutrition research in various centres in India. Some 13 enquiries are being financed at the present time. It has established nutrition research units in Dacca and Bombay respectively. In

Calcutta there is a department of biochemistry and nutrition in the All-India Institute of Hygiene and Public Health, and a nutrition section is being developed in the Haffkine Institute, Bombay. Workers in these units could be utilised for advisory work on nutrition.

(d) **Nutrition workers in provincial health departments.**—The policy of including nutrition workers in the health departments of provinces and the larger states was initiated by the Nutrition Advisory Committee in 1936. Facilities for training were provided in Coonoor. Though not all governments have responded, some progress has been made. At present there are nutrition officers in the health departments of the Punjab, Bihar, Madras and Hyderabad. In Orissa, Travancore, Cochin, Sind and in certain States there are workers in the health and medical departments who have taken the course in Coonoor but are not specifically employed in nutrition work. In Bombay a nutrition officer has recently been appointed in the Food Department. Public health nutrition workers have been largely concerned with surveys of diet and state of nutrition, investigations of deficiency diseases and propaganda work. In general, health departments have not as yet linked up with food departments in connection with food policy in its broader aspects. There are, however, signs in various Provinces of developments in this direction.

(e) Mention may also be made of a nutrition course in Madras which is part of the Domestic Science course of the University. This has been organised in the Women's Christian College, Madras, with my advice and assistance. One class of about 12 members has completed the nutrition course, and the second class is nearing its end. Some of the graduates who have taken the course might be employed in educational and propaganda work. We have had this in mind all along. Ladies with a training in nutrition might be very useful for popularising suitable recipes and dishes.

(6) SCARCITY OF NUTRITION WORKERS

The need for developing nutrition research in India has repeatedly been emphasised by the N. A. C. The N. A. C. has drawn up a detailed programme of future nutrition research, including clinical research, which cannot be developed without a larger body of workers. At the moment the ranks of nutrition research have been depleted by the departure of workers to other employment. For example, the Director of Nutrition Research has during the last two years spent most of his time in attending committees and conferences and in advisory work in general, and is now a full-time member of the Famine Inquiry Commission. Other workers have gone into the army and the Central Food Department.

In England a group of nutrition workers under Sir Jack Drummond has been attached to the Ministry of Food. Problems on which the Ministry requires information and research can also be referred to various laboratories in which there are workers of long experience and high standing, *e.g.*, the Dunn Nutritional Laboratory and the Lister Institute of Preventive Medicine. In India there is no such wealth of workers or institutions. If workers actually engaged in nutrition research are diverted to advisory work in association with food

departments the number of the former will be still further reduced. Research workers who are diverted to advisory work for long periods are inclined to "dry up" for lack of contact with advancing research and need refreshment by return to research activities. It is desirable, in connection with the future development of the work of food departments in India, to consider the need of training more nutrition workers and thus avoid seriously weakening the existing research organisations.

The question of the provision of nutrition specialists for food departments needs careful consideration and discussion. The Health Survey and Development Committee has accepted the report of the N. A. C. which strongly recommends the creation of nutrition sections in public health departments. The question arises whether it would not be better for nutrition officers in such sections to link up with food departments, than to create another nutritional organisation in connection with food administrations. The whole problem of developing food administrations on the nutritional side must be considered in relation to nutrition organisations and personnel at present available.

(7) INSTRUCTION IN NUTRITION TO WORKERS IN FOOD DEPARTMENTS

With regard to immediate needs, a temporary solution might be to arrange for individuals chosen by food departments to attend a special course on nutrition in Coonoor, lasting for about 4 weeks in April or May 1945. Men and women with some scientific background should, if possible, be selected for this purpose. It is impossible to create a nutrition expert in 4 weeks, but at least a general idea of the subject could be imparted within this period. Senior officers in food departments might appreciate a short course of instruction in nutrition.

Finally, it may again be emphasised that the time is ripe for a great forward drive to raise standards of nutrition in India. The problem is a large and complicated one, demanding action in many different fields for its solution. The newly created food departments can play a most important part in the campaign.

NEW DELHI,
15th December, 1944.

MINISTRY OF HEALTH

ADVISORY COMMITTEE ON NUTRITION

FIRST REPORT

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Advisory Committee on Nutrition

CONSTITUTION AND TERMS OF REFERENCE OF COMMITTEE.

We hereby appoint—

The Lord Luke, K.B.E., J.P.
 Mrs. Eleanor Barton, J.P.
 J. N. Beckett, Esq.
 G. F. Buchan, Esq., M.D., F.R.C.P.
 Professor E. P. Cathcart, C.B.E., M.D., D.Sc., F.R.S.
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 Mrs. Chalmers Watson, C.B.E., M.D.
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 E. H. T. Wiltshire, Esq.

to be an Advisory Committee to inquire into the facts, quantitative and qualitative, in relation to the diet of the people, and to report as to any changes therein which appear desirable in the light of modern advances in the knowledge of nutrition.

The term of office will expire on the 31st July, 1938, and retiring members will be eligible for reappointment.

We further appoint the Lord Luke to be Chairman and Mr. W. J. Peete of the Ministry of Health and Mr. N. F. McNicoll of the Department of Health for Scotland to be Secretaries and Dr. H. E. Magee of the Ministry of Health to be Medical Secretary of the said Committee.

(Signed) E. HILTON YOUNG,
 Minister of Health.

(Signed) GODFREY P. COLLINS,
 Secretary of State for Scotland.

30th May, 1935.

We hereby appoint T. W. Wade, Esq., M.D., Senior Medical Officer of the Welsh Board of Health, to be a member of the Advisory Committee on Nutrition appointed on the 30th May, 1935.

(Signed) KINGSLEY WOOD,
Minister of Health.

(Signed) GODFREY P. COLLINS,
Secretary of State for Scotland.

10th July, 1935.

We hereby appoint E. M. H. Lloyd, Esq., to be a member of the Advisory Committee on Nutrition which was appointed on 30th May, 1935.

Dated this twenty-fourth day of July, 1935.

(Signed) KINGSLEY WOOD,
Minister of Health.

(Signed) GODFREY P. COLLINS,
Secretary of State for Scotland.

We hereby appoint Miss Ruth Pybus to be a member of the Advisory Committee on Nutrition in the place of Mrs. A. M. Chalmers Watson, C.B.E., M.D., deceased.

Dated this 24th day of November, 1936.

(Signed) KINGSLEY WOOD,
Minister of Health.

(Signed) WALTER E. ELLIOT,
Secretary of State for Scotland.

The estimated gross cost of the preparation of this Report (including the expenses of the Advisory Committee) is £401 7s. 3d., of which £54 10s. 0d. represents the estimated gross cost of printing and publishing the Report.

ADVISORY COMMITTEE ON NUTRITION

FIRST REPORT

To the Right Honourable Sir H. KINGSLEY WOOD, M.P.,
Minister of Health, and

The Right Honourable WALTER E. ELLIOT, M.C., M.P., His
Majesty's Secretary of State for Scotland.

SIRS,

We, the Advisory Committee on Nutrition, have the honour to submit this, our First Report.

I.—INTRODUCTORY.

1. Terms of Reference.—In 1931, a small Committee composed mainly of physiologists was appointed to “advise the Minister of Health on the practical application of modern advances in the knowledge of nutrition.” The present Committee was appointed on the 30th May, 1935, by the Minister of Health and the Secretary of State for Scotland, with the following terms of reference—

“To inquire into the facts, quantitative and qualitative, in relation to the diet of the people, and to report as to any changes therein which appear desirable in the light of modern advances in the knowledge of nutrition.”

2. We have appointed three standing sub-committees:—

- (1) Statistical,
- (2) Economic and Social,
- (3) Physiological,

and the sub-committees have themselves appointed further sub-committees for some special purposes. The Main Committee and sub-committees have held some 40 meetings.

We have not taken any formal evidence but numerous memoranda and publications have been submitted to us.

3. Our terms of reference are much wider than those of the former Committee, and involve investigations more comprehensive in scope and character and likely to prove more fruitful than any hitherto attempted. Two fundamentally different questions are proposed to which we are asked to furnish replies.

4. The first question is one of fact, what foods and what amounts of each are consumed by the nation, and how the total consumption of these foods is distributed among the individual men, women, adolescents and children of all sorts and conditions who make up the nation.

5. The second question—as to any changes which appear desirable—calls on the other hand, not for the laborious collection and competent handling of statistical material, but for a considered opinion, in the light of this material, on the application of the lessons of recent nutritional science to the feeding of the nation.

6. We believe that this is the first occasion in history that a comprehensive survey, statistical and physiological, of the diet of a whole nation has been set on foot by any Government.

7. **Scope of Report.**—In this first Report we are giving the results of our preliminary survey of the whole field. We are very far from having completed our investigations, and in several directions we have initiated large-scale inquiries which are only just beginning. But in view of the wide popular interest in food and nutrition we have felt it incumbent upon us to present this Report, sketching in outline the nature of the problem and the general picture we have formed of the present position.

8. The particular questions to which we have addressed ourselves are:—

(i) Is there sufficient food produced in and imported into the country to ensure for everyone a diet in conformity with the principles of modern knowledge?

(ii) Are the diets of different sections of the population adequate in every respect in the light of recent advances in the knowledge of nutrition?

(iii) Is the state of nutrition* of every section as good as it could be made by the application of modern knowledge?

9. In attempting to answer these questions, our first task was to collect all relevant information from existing records, to classify it, and to determine its limitations and defects. The next step was to devise and initiate plans to fill the gaps in our knowledge. The present Report is mainly an account of these activities.

10. We have conceived it to be our task to indicate in what directions changes in the nation's diet are desirable rather than to show how these changes can be brought about by economic or

* We have interpreted the term "state of nutrition" as applying to the physical and functional bodily condition only in so far as it is dependent on food.

political action. Although this Report is mainly a review of our work, we have prefaced it with two preliminary chapters, one dealing with present knowledge of nutrition, the other giving a general picture of the national food supply. Finally, we have drawn some tentative conclusions as to the changes in the national diet which appear desirable.

II.—RECENT ADVANCES IN THE KNOWLEDGE OF NUTRITION AND THEIR APPLICATION.

11. **The new Outlook in Public Health.**—During the past quarter of a century there has been taking place a change of attitude of far-reaching importance towards health problems. This development is finding expression in the adoption to an increasing extent of positive measures to promote health, whereas formerly the main concentration of effort was on improvement of environmental conditions and the cure of disease. The facts brought to light in the remarkable series of discoveries in the science of nutrition in recent years have quickened this change of outlook.

12. These discoveries, which are the result of experimental work and clinical observations, make it clear that if the diet is unsuitable, the body cannot be properly constructed, neither can it function effectively. Here, of course, we include the maternal diet during intra-uterine life.

13. Other factors such as the age incidence and the sequelae of infectious disease, the emotional state, occupation, housing conditions and amount of sleep and exercise also affect development and health. These factors, important as they are, fall outside the scope of our inquiry.

14. **The Modern Knowledge of Nutrition.**—Before the principles of the recent knowledge of nutrition were established, conceptions of human nutrition were confined almost entirely to protein and energy requirements, and to the mode of utilisation of proteins, fats and carbohydrates by the body. Recent discoveries have shown that various mineral elements and vitamins play roles as essential in the economy of the body as those played by the proteins, fats and carbohydrates, and, in addition, that proteins of animal origin are generally of higher nutritional value than those from the vegetable kingdom. That is to say, they are superior for the construction of the body and repair of tissues. It is now well known that deficiency of suitable protein or of any one of the essential mineral elements or vitamins results in a disorganised state of nutrition. Some of these conditions, such as florid rickets and scurvy, are well defined and easily recognisable, while clinical and

experimental evidence is accumulating which suggests that many vague disturbances of health may be related to slight dietetic errors. We believe that better physique and health can be obtained and resistance to disease increased by the application to human diets of recent knowledge which demonstrates the importance of certain classes of food for proper nutrition.

15. "*Protective*" Foods.—The term "protective" in relation to foods was originally given by McCollum to milk and green vegetables because they correct the most common deficiencies of diets and thereby "protect" the consumer against such deficiencies. Liver, other glandular tissues and eggs are sometimes described as protective foods but they cannot replace milk and green vegetables, the protective foods properly so called. Although the word "protective" as frequently used at present has lost its original meaning to some extent, it is nevertheless a convenient collective term to apply to foods rich in those nutrients which research has shown to be essential for health. In short, the recent advances in knowledge of nutrition consist chiefly in the series of facts which have been revealed concerning the physiological roles of the foods now designated "protective." The most important of these foods are milk (and milk products), green vegetables, fruit and eggs.

16. **Application of Recent Advances in Nutrition.**—The new facts which have been brought to light are so numerous and so difficult for the layman to grasp that the application of this knowledge might be supposed to be impossible by the majority of people. Fortunately, the practical application of this knowledge can be expressed in a few simple statements. The most essential is that correct feeding is more important for expectant and nursing mothers and young children than for other members of the community, and the younger the child the more important it is that it should be properly fed, for the effects of a dietary deficiency during childhood or adolescence may persist through life. Finally, inclusion of adequate quantities of the protective foods in the diet will ensure correct nutrition, since, given adequate resources, most people instinctively consume sufficient of the energy-giving foods. The practical application of the recent advances in the knowledge of nutrition, therefore, consists simply in the inclusion in the dietary of the whole community of sufficient amounts of the protective foods; this is especially important for mothers and children, on whose good health the future of the nation depends.

17. **Results of the Application of Modern Knowledge of Nutrition.**—The public health services, whose aim is the maximum of well-being for the whole community, have been

adopting and applying these discoveries to practical health problems. During the last quarter of a century, the general death rate, the infant mortality rate and the death rate from tuberculosis have fallen. Gross rickets has become less common, chlorosis has almost disappeared, and the physique of school children has been steadily improving. Amongst the factors contributing to these advances in the public health are the efforts of the public health services to secure the application of the discoveries in nutrition, and the improvement in the national dietary as a result of the general rise in the standard of living, combined with the greater availability of foods of the right kinds, such as butter, cheese and fruit.

18. The diet of the people is now more in conformity with physiological principles than it was in pre-war years, and one of the reasons for this advance is the educational work on nutrition carried out in health clinics and in schools throughout the country. The Health and Education Departments of the Government have played their part in this work by the issue of memoranda and instructions on nutrition to Local Authorities. Amongst these publications, special mention must be made of the Memoranda issued by the former Advisory Committee on Nutrition, "The Criticism and Improvement of Diets"* and "Diets in Poor Law Children's Homes."* Local Authorities have derived considerable advantage from these memoranda, not only in the revision of diets in institutions and open-air schools, but also in instructing mothers and the older school children in dietetics. The careful attention given by Local Authorities during the past decade to the state of nutrition of mothers and children, and the giving of milk, meals, and other supplements, free, or at reduced cost, have unquestionably led to improvements in the national dietary and thus have had beneficial effects on the health of the people.

19. Although much has been achieved, much still remains to be done before the general health and physique of the population reach the optimum level. It must not, for example, be overlooked that in 1935, tuberculosis was still responsible for 32,903 deaths (England, Scotland and Wales), 6.1 per cent. of the total mortality, or that the mortality rate from all causes in children aged one to four years, favourable as is its trend, is distinctly higher than that of certain other countries, notably Norway, Sweden and the Netherlands. Moreover, the numerous milk feeding experiments which have been carried out demonstrate how physique in childhood might be improved. There is thus ample room for further progress, and we believe that the improvements in diet referred to will play an important

part in attaining this end. The science of nutrition is, however, still in its infancy and future research will undoubtedly make many more contributions to knowledge which will be of lasting benefit to mankind. But, even now, sufficient facts have been accumulated to justify the hope that their general application would result in improved health, physique, and increased resistance to disease.

20. International Recognition of the Significance of Recent Knowledge of Nutrition.—The significance of the science of nutrition is now realised in all civilized countries, and the increasing attention which Governments have been giving to the subject culminated in its being discussed at the Assembly of the League of Nations in September, 1935. Since that time the Health Committee of the League has issued several reports on the subject; one of these, that on the Physiological Bases of Nutrition (June, 1936),* will be referred to later. The delegates agreed that the diets of many people, even in the most prosperous countries, fall short of that degree of perfection which we know is desirable. The fact that the United Kingdom cannot be excluded from this generalisation has been obvious for many years to the Health Departments of the Government and to Local Authorities, as well as to research workers in nutrition. In fact, many of the public health measures which have been adopted in recent years, such as the provision of milk for mothers and children, are in themselves an admission that the home diets of some sections of the people fall short of the requirements which are essential for health.

III.—THE NATION'S FOOD.

21. Food Consumption in 1934-5.—It is by no means easy to say what is the total quantity of each food consumed by the population of the United Kingdom.† At our request careful estimates have been compiled by Departments for the two years 1934 and 1935, and owing to seasonal variations in home production, particularly of fruit, we decided to take the average of these two years (see Table 1, page 13, and Appendix I). Fresh milk, potatoes and certain vegetables are the only foods produced almost entirely in this country, but nearly 90 per cent. of the fish and nearly 70 per cent. of the eggs in shell consumed in this country are derived from home sources. Rather more than half the total meat consumed is imported, and about 70 per cent. of the cheese and sugar,

* Ser. L.o.N.P. 1936. II.B.4.

† The available data all relate to the United Kingdom and not to England and Wales and Scotland separately.

and 90 per cent. of the cereals and fats. The United Kingdom is the largest food-importing country in the world, and this fact has been associated with a relatively high standard of food consumption. It is significant that the chief contribution of home agriculture has been in the supply of foods of special importance for nutrition—milk, green vegetables and potatoes.

22. Changes in Consumption.—Comparison of these estimates of total food supplies with similar estimates for earlier periods (see Table II, page 16) shows that for many years, (except during the war), there has been a progressive increase in the consumption per head of most foodstuffs, and that the increase has continued since the war. The chief exception is the consumption of cereals, which has fallen by nearly 10 per cent. since 1909-13. This fact, taken in conjunction with the increased consumption of other foods, is evidence of improvement in the national dietary and of a rise in the standard of living. But there is one important exception to the general improvement—consumption of liquid milk per head of the population apparently declined slightly between 1909-13 and 1934-35. This decline has been approximately off-set by a four-fold increase in the consumption of dried and condensed milk; but it remains true that consumption of milk in all forms per head of the population is too low.

23. Comparison with Optimum Standards.—Our next objective was to compare the quantities of food available with the nutritional requirements suggested by the Technical Commission* of the League of Nations Health Organisation. It is not easy to make an exact comparison, partly because the League Commission was, of course, unable to prescribe optimum quantities for all foods, and partly because no precise allowance can be made in the statistics relating to foods available for consumption to cover wastage in distribution and in the home. However, a very rough comparison has been made with the following results:—

(a) *Calories.*—It has been computed that in the average of the years 1934 and 1935 the national food supply contained 55,700 thousand million calories, or, allowing for a wastage of 10 per cent., 50,100 thousand million calories (net), as compared with total estimated net requirements for the population of 44,300 thousand million calories on the basis of the Report of the League Commission. Thus there is

* Referred to throughout this Report as "the League Commission."

a fair margin of calories available over calories required, and we regard this result as having satisfactory significance. We conclude from this and from the results of dietary surveys that there is no lack of energy-giving foods in the national food supply. In our opinion, all—except a relatively small fraction of the population—are obtaining the full amount of calories they require.

(b) *Fats*.—The marked increase in consumption of fat which has occurred in recent years suggests that there is no aggregate deficiency in the national diet; but there is some deficiency among the very poorest.

(c) *Proteins*.—The total protein supplies of animal and vegetable origin are estimated at 1,490,000 metric tons,* or allowing for an over-all wastage of 10 per cent., 1,340,000 metric tons. Requirements based on the League Commission's recommendations have been computed at 1,180,000 metric tons. We may conclude, therefore, that the national diet contains a sufficiency of protein; but this conclusion is subject to the qualification that the consumption of animal protein increases while that of vegetable protein remains nearly constant as the standard of living rises with income. Although there is no recognised standard requirement of animal protein, it is probable that there is some shortage of this constituent in the diets of the poorest section of the community.

(d) *Milk*.—The most significant comparison between national consumption and the League Commission's recommendations first made in its preliminary Report in December, 1935, relates to liquid milk. In view of the nutritional importance of milk, particularly for mothers, children and adolescents, we prepared a special memorandum entitled "The Nutritive Value of Milk,"† which was published in March, 1936 (*vide* Appendix II). We have computed that the requirements suggested by the Commission and adopted in our Memorandum are equivalent to an average allowance per head of the population of the United Kingdom of seven-eighths of a pint of liquid milk daily. The present national consumption of liquid milk is less than one half of this amount. If condensed and dried milk are included, the national consumption is still only 60 per cent. of the amount suggested by the Commission. We

* A metric ton=1,000 kilos or 2,204 lbs.

† H.M.S.O., 1936, price 3d. net.

regard this deficiency with special concern and we find it necessary to refer to it repeatedly throughout our Report.

(e) *Fruit and Vegetables*.—As regards other foods, the nutritional optimum is less easy to define and we prefer at this stage to make no quantitative comparisons, especially since the League Commission has not suggested any standard requirements. There is, however, good reason to believe that the national consumption of fruit and vegetables is below the nutritional optimum, and that this deficiency is predominantly to be found in the poorer sections of the population.

24. Recommended Increase of Milk Consumption.—We have expressed the opinion in our Memorandum on "The Nutritive Value of Milk" that the desirable amount of milk for children is from one to two pints per day, for expectant or nursing mothers about two pints per day, and for other adult members of the community half a pint of milk daily. If these quantities were consumed, the present consumption of liquid milk would be at least doubled.

25. In this connection it is not for us to discuss the vexed economic and political questions involved in the control of the price of liquid milk, but we deplore the fact that, while the volume of milk offered for sale is growing and there is a substantial surplus which it is beyond the capacity of the liquid milk market to absorb, there should be at the same time a severe deficiency of milk in the diet of large sections of the population. That under-consumption of a foodstuff so important as milk should exist in a country so eminently suited for milk production, is a matter towards which we cannot remain indifferent.

26. In recent years, measures have been taken to provide milk, free or at a reduced price, to necessitous mothers and children, including necessitous school-children. The Milk-in-Schools Scheme, which enables children of school age to get one-third of a pint daily for a half-penny, is another important step in the right direction. These measures are valuable so far as they go; but they do not provide sufficient milk for all mothers and children who need it, and very little provision is made for adolescents.

27. We hope that in dealing with the problem of milk, now and in the future, the primary objective of the State will be

to ensure that a supply of safe milk, to the amount we have recommended in paragraph 24 above, is brought within the purchasing power of the poorest.

28. The national advantages of an improved standard of health for the rising generation cannot be expressed in pounds, shillings and pence; but even from the point of view of industrial efficiency, it is not over-stating the case to say that a high general standard of physical well-being is the nation's greatest asset.

29. From the health standpoint there is no other single measure which would do more to improve the health, development and resistance to disease of the rising generation than a largely increased consumption of safe milk by mothers, children and adolescents.

IV.—FOOD STATISTICS.

30. **Total Food Supplies.**—No official statistics as to the total food consumed in the United Kingdom are regularly compiled and published, but the Market Supply Committee provided us with the preliminary results of its study of the market for various foodstuffs, in the course of which it had made estimates of total food supplies in 1934 and 1935. These estimates have been revised in consultation with the Board of Trade and the Agricultural Departments and are given in full in Appendix I. They are summarised in Table I, which shows also the approximate percentages of imported and home produced food.

31. The chief elements of uncertainty in estimates of total food supplies are the allowances to be made for milk used on the farm, for eggs, fruit and vegetables produced in private gardens and on holdings of less than one acre, and for home grown food consumed in the farmers' own households.

TABLE I.
Foodstuffs for Human Consumption—United Kingdom.
Average of the two years 1934 and 1935.

	<i>Total.</i> <i>ooo tons.</i>	<i>Per cent.</i> <i>Imported.</i>	<i>Per cent.</i> <i>Home</i> <i>Produced.</i>
Flour from wheat and other cereals	4,427	87	13
Meat (including bacon)	3,062	51	49(a)
Fish (excluding freshwater fish)	953	12	88(b)
Milk (million gallons)	910	—	100(a)
„ Condensed and dried	253	38	62(a)
Cream	37	11	89(a)

	<i>Total.</i> <i>ooo tons.</i>	<i>Per cent.</i> <i>Imported.</i>	<i>Per cent.</i> <i>Home</i> <i>Produced.</i>
Fats (butter, lard and margarine) ...	888	92	8(a)
Cheese... ..	203	69	31(a)
Eggs	430	39	61(a)
Fruit	2,432	77	23
Potatoes	4,629	3	97
Other Vegetables	2,425	25	75
Sugar	1,958	73	27

(a) Partly dependent on imported feeding stuffs.

(b) After allowing for herrings exported. Home produced fish means British takings landed by British vessels.

32. As already observed, fresh milk and potatoes are the only foods produced almost entirely in this country. More than half of the fish, vegetables other than potatoes, eggs, cream and condensed milk are produced at home. Rather more than half the total meat supplies, about 70 per cent. of the cheese and sugar, nearly 80 per cent. of the fruit, and about 90 per cent. of the cereals and fats are imported.

33. In terms of energy value or calorie equivalent,* home production represents about 40 per cent. of total consumption; but reckoned in terms of retail value it is estimated by the Market Supply Committee that home produced food is nearly half the total supply. The latter estimate is more significant for our present purpose since many of the foods of special nutritional value are expensive in relation to their energy value (particularly milk, eggs and vegetables). Home produced livestock products—meat, eggs and dairy produce—depend, however, to a considerable extent on imported feeding stuffs. It has been roughly estimated that about a quarter of the home produced meat and milk is produced from imported feeding stuffs.

34. **Wastage.**—The figures in the above Table are the gross figures of supplies available without taking into account wastage in distribution. The amount of wastage varies with every food and is difficult to estimate accurately. In order to translate the gross quantities of food available for consumption and of food purchased into their equivalent nutritive values, however, the necessary allowances must be made for wastage. Wastage takes place both before purchase by the consumer and in the household after purchase. In the case of meat, some of the bones in the dressed carcass are not sold to the consumer, the proportion being greatest for beef, where it is estimated at 15 to

* On the scale adopted by the Committee of the Royal Society on Food Supplies of the United Kingdom in 1916.

20 per cent. In regard to wastage in the home, for example, it was found in a dietary survey of 50 families in Newcastle-upon-Tyne* that bones and other portions of meat not eaten amounted to about 10 per cent. of the quantity prepared for consumption. Inedible portions of potatoes, other vegetables and fish amounted to about 20 per cent. and of fruit to 23 per cent. Moreover, unknown amounts of food are consumed by cats and dogs. For these reasons the figures in Tables I and II are an over-estimate of the amount of food actually consumed by the population.

35. Consumption per Head in 1934-5 compared with 1924-8 and 1909-13.—It is of interest to compare figures of total food supplies in 1934-5 with similar estimates for past years. In Table II overleaf, foods available for consumption per head per week for the United Kingdom in 1934-5 are compared with the average of the five years 1924-8 and the average of 1909-13, as estimated by Sir Alfred Flux in 1930.† It should be noted that in 1909-13 the United Kingdom included the area and population of what is now the Irish Free State. Allowance has, of course, been made for the change in the numbers of the total population of the United Kingdom at the various dates; but it has not been possible to estimate the probable effect of the change in the consumption habits of the population caused by the transference of the Irish Free State, a predominantly rural area, from the United Kingdom. This factor mainly accounts for the apparent fall in the consumption per head of potatoes (see footnote below).‡

* Unpublished results.

† Journal of the Royal Statistical Society, Vol. XCIII, Part IV, 1930.

‡ If food consumption in the Irish Free State, as given by the High Commissioner for the Irish Free State for the year 1934-5, is added to the United Kingdom figures, the comparison between 1909-13 and 1934-5 is as follows:—

*Consumption per Head per Week—British Isles
1909-13 and 1934-5.*

	1909-13.	1934-5.	Percentage Increase (+) or Decrease (-) 1934-5 on 1909-13.
Meat	2.58 lb.	2.75 lb.	+ 6.6
Cereals (including wheat and flour)	4.45 lb.	4.10 lb.	- 7.9
Potatoes	4.68 lb.	4.63 lb.	- 1.0
Other Vegetables	1.38 lb.	2.25 lb.	+ 63.0
Milk and Cream	3.46 pints	3.33 pints	- 3.8
Eggs	1.93	3.03	+ 57.0
Butter	0.30 lb.	0.51 lb.	+ 70.0
Sugar	1.52 lb.	1.79 lb.	+ 17.8
Fish	0.79 lb.	0.83 lb.	+ 5.0
Tea	0.12 lb.	0.18 lb.	+ 50.0

TABLE II.

Consumption per head per week—United Kingdom, 1909-13, 1924-8 and 1934-5.

—	1909-13.	1924-8.	1934-5.	Increase (+) or Decrease (-) of 1934-5 compared with	
				1909-13.	1924-8.
	lb.	lb.	lb.	per cent.	per cent.
Meat (including poultry, etc.)	2.58	2.56	2.81	+ 9	+ 10
Cereals (including wheat and flour)	4.45	4.11	4.04	- 9	- 2
Potatoes	4.68	4.43	4.25	- 9	- 4
Other Vegetables ...	1.38	1.81	2.22	+ 61	+ 23
	pts.	pts.	pts.		
Milk and Cream ...	3.46(a)	3.35(a)	3.26	- 6	- 3
	lb.	lb.	lb.		
Condensed Milk ...	0.05	0.14	0.23	+360	+ 64
	No.	No.	No.		
Eggs, in shell ...	1.93	2.34	2.90	+ 50	+ 24
	lb.	lb.	lb.		
Butter	0.30	0.31	0.49	+ 63	+ 58
Margarine	0.11	0.23	0.15	+ 36	- 35
Cheese	0.14	0.18	0.19	+ 36	+ 6
Lard	0.08(b)	0.11(b)	0.18	- (c)	- (c)
Sugar	1.52	1.60	1.79	+ 18	+ 11
Fish... ..	0.79	0.80	0.87	+ 10	+ 9
Fruit	1.19	1.75	2.23	+ 87	+ 27
Tea	0.12	0.17	0.18	+ 50	+ 6

(a) These estimates for milk may be somewhat too high.

(b) Lard made in the United Kingdom is included in meat.

(c) Not comparable.

These figures include wastage in distribution and in the home and consumption by domestic animals.

36. The consumption per head of most foodstuffs has increased since before the war. The largest proportionate increases have been in condensed milk, fruit, butter, vegetables (other than potatoes), eggs, tea, margarine and cheese. Large increases in the consumption of condensed milk and butter have also taken place during the last ten years. The consumption of butter and margarine together is now 56 per cent. higher than before the war. The consumption of cereals has fallen by nearly 10 per cent. since 1909-13, and that of milk and cream by about 6 per cent.

37. **Trends of Milk Consumption.**—During the year ended 30th September, 1934, according to the statistics of the Milk

Marketing Boards* about 950 million gallons of milk were sold off farms in Great Britain. Of this total, about 700 million gallons were absorbed by the liquid milk market and 250 million gallons went for manufacture. In the following year ended 30th September, 1935, the quantity sold into the liquid milk market was 745 million gallons, and the quantity sold for manufacture 361 million gallons. It is estimated that in the year ended 30th September, 1936, 753 million gallons were sold into the liquid milk market and the amount used for manufacture was 410 million gallons. Thus, there has been an increase of 64 per cent. in the quantity used in manufacture since 1934. This milk is, of course, utilised for the preparation of cheese, butter, condensed milk, fresh cream and other products all of which are intended for human consumption.

38. The total supply of liquid milk for human consumption in the United Kingdom (including the amount consumed in farm households), which is estimated at 910 million gallons a year for 1934-5, (see Table I), together with the liquid milk equivalent of condensed and dried milk, amounts to not more than half a pint per head per day. This figure is low compared with the estimated milk consumption in certain other countries, notably Scandinavia and the United States of America.

39. The need for an increase in the consumption of milk per head is a matter to which special attention is directed in Sections III and VI. One factor which may have contributed to the fall in milk consumption per head is a change in the age distribution of the population, the proportion of children being less now than before the war, and more milk being required by children than by adults. On the basis of the standard requirements which we have adopted,† the average standard milk requirement per head of the population fell by 7 per cent., which is practically the same as the percentage by which the consumption per head of fresh milk and cream apparently declined between 1909-13 and 1934-5. On the other hand, dried and condensed milk consumption has increased more than four-fold. It therefore appears that consumption of milk in all forms per head, standardised to a constant age composition of the population, actually shows a slight increase of about 4 per cent. Much of the dried and condensed milk, however, is used in confectionery and most of the remainder is in the form of condensed skimmed milk, which is not equivalent in its constituents to fresh whole milk.

* It should be observed that Milk Marketing Boards' statistics of liquid milk consumption are about 10 per cent. lower than the estimate based upon agricultural returns and family budget inquiries, i.e., 2·8 pints per head per week compared with 3·1.

† See paragraph 24.

40. General Conclusion from Food Statistics.—The available information presented above indicates that although milk consumption per head has remained practically stationary at a low level, there has undoubtedly been a general improvement in the national diet since before the war.

41. Conversion Factors.—In assessing the value of the national food consumption in terms of the actual quantity of nutrients consumed, it is necessary to have reliable conversion factors for individual foods. An investigation was started by one of our special sub-committees to ascertain the proportions of protein and fat in different varieties of meat. Results so far obtained indicate that there are a higher proportion of protein and a lower proportion of fat in bacon and ham than in the earlier analyses of Atwater and Plimmer. Some details of this research are given in Appendix IV.

42. Variation in Food Consumption at Different Income Levels.—The object of the Market Supply Committee's study of the market for foodstuffs was to ascertain not merely total supplies and average consumption, but some measure of the probable variation in consumption at different income levels.* This information was needed in order to give a broad picture of the actual and potential market for foodstuffs both for the Market Supply Committee's own use in making recommendations under the Agricultural Marketing Act, 1933, and for the guidance of Marketing Boards and other bodies interested in securing increased consumption of particular foods. The data used in the Market Supply Committee's investigations comprised estimates of total consumption of and expenditure on each food, family budget material and an estimate of the distribution of the national income by income groups. Owing to the incompleteness of the data, many of the estimates are only rough approximations.

43. Our Statistical Sub-Committee was asked to report on (i) the adequacy of the available data for making estimates of food consumption at different income levels, (ii) the degree of probability attaching to the estimates of the Market Supply Committee and (iii) the data required for making a closer approximation to the true position.

44. After examining the data and the methods employed, the Sub-Committee did not discover any reason to suggest that the results arrived at by the Market Supply Committee are seriously misleading, or that they are more likely to err in one direction than another, but they realised that the results are based upon a slender foundation. The weakest point in the calculations

* See "Food Supplies and Consumption at Different Income Levels," by E. M. H. Lloyd, *Journal of Proceedings of the Agricultural Economics Society*, Vol. IV, No. 2, April, 1936.

is the uncertainty with regard to the distribution of working-class earnings, as to which no statistical returns are at present available. In general we are satisfied that no better estimates of variations in food consumption could have been made from the available data.

45. It is clearly impossible to determine with absolute precision the average level and variability of food consumption in different income groups since this would require a knowledge of the diets of millions of households. With the present relative paucity of data and the consequent complexity and uncertainty of many of the detailed calculations, it is certainly possible that there may be a considerable margin of error in the estimate of the average level of consumption of any particular article of food within any income group. On the other hand, the conclusions as to the broad trend of consumption of the different articles of food over the income groups appear to us likely to be in accordance with the facts. For example, the consumption per head of the more expensive foodstuffs which are those specially important for health—fresh milk, butter, meat, fish, eggs, fruit and vegetables (other than potatoes)—rises progressively with income; that of the cheaper staple foods, such as flour and potatoes, remains nearly constant, while the consumption of margarine and condensed milk decreases as income rises. The variation in consumption between the highest and lowest income groups is greatest in the case of milk, fruit and vegetables (other than potatoes). The consumption of meat varies less than that of fish or eggs. The highest consumption of tea, cheese and the fats (lard, suet and dripping) is reached in the middle groups, while sugar and jam increase at first and then remain fairly constant.

V.—PHYSIOLOGICAL BASES OF NUTRITION.

46. **Report of League Commission.**—At its 22nd Session in October, 1935, the Health Committee of the League of Nations resolved that a Technical Commission should be appointed to define the nutritional needs of the human being in the course of development from conception to the adult age, that is, the physiological bases for adequate nutrition. Three of our members (Professor Cathcart, Professor Mellanby and Sir John Orr) were appointed as members of the Technical Commission and Professor Mellanby was elected Chairman. Our Physiological Sub-Committee considered the first report of the Commission, issued in December, 1935, and made certain suggestions which were brought to the notice of the Commission. Most of these were adopted when the report was revised and amplified at the meeting of the Commission held at Geneva at the beginning of June, 1936. The revised report has also been considered and an extract from it is given in Appendix III.

47. The Commission endorses the earlier report by Drs. Burnet and Aykroyd, which reviews the position of nutrition in relation to public health in the civilised countries of the world, and concludes that deficiencies in protective foods occur frequently in modern diets. In Part I of the revised report, standards for energy and protein requirements are suggested. These do not differ materially from those agreed to by other authorities in recent years. The Commission did not express the standards for energy and protein in terms of actual foods, nor did it state how the energy requirements should be apportioned between protein, fat and carbohydrates. Part II of the revised report deals with mineral and vitamin requirements and thus embodies the outstanding discoveries in nutrition during the past 30 years. The needs for perfect nutrition are suggested in terms of specified quantities of the protective foods. The level of nutrition set by the Commission is the optimum level and to attain this sufficient quantities of the protective foods are essential. In order to emphasise the great importance of ensuring optimum nutrition for the coming generation, the Commission concentrated their attention in the first instance on children, and on expectant and nursing mothers.

48. The Tables appended to its report contain some simple schedules to show how a selection of common protective foods can be made to ensure safe intakes of the necessary proteins, minerals and vitamins for expectant or nursing mothers, for infants and for children up to 14 years. The selection of the additional foods necessary to provide the full quota of calories is left to the individual. No attempt is made to lay down a detailed dietary programme, or to suggest the wide range of protective and energy yielding foods whose selection will be influenced by availability, appetite and cost.

49. We note with approval that the Commission gives special emphasis to the importance of milk in the diet at all ages, and in its dietary schemes for pregnant or nursing women and for children up to the age of 14 years the Commission recommends the provision of large proportions of milk.

50. Subject to some minor reservations,* we desire to record our general agreement with the report. It aims at a high level of nutrition which, if widely adopted, would undoubtedly improve the health of the community and be of particular advantage to the rising and future generations.

* We think that the recommended allowance of two grammes of protein per day per kilogramme of body weight for the nursing woman is on the high side, and that 1.5 grammes would be a more suitable allowance. No indication is given of the amount of fat which it is desirable that an adult should consume. We also deprecate the irradiation of milk which the Commission appears to have recommended or at least to have excepted from their general condemnation of indiscriminate irradiation. These matters will no doubt receive further consideration when the Commission again reviews the report.

51. Application of League Commission's Suggestions.—It is difficult to make a direct comparison between the recommendations of the League Commission and the diets of the different social groups of the population as a whole, because the Commission has not formulated a dietary schedule applicable to an average person. Some calculations from the data available have enabled us, however, to make some broad general deductions.

52. Milk.—For instance, it is possible to arrive at the approximate milk requirements of the average person in the population at the Commission's suggested level of nutrition on the basis of calcium intake, which is the basis of the estimate of seven-eighths of a pint daily mentioned in paragraph 23 (*d*).

53. Eggs.—As regards eggs, the present national average consumption is estimated to be 2·9 per head per week. The suggested schedules of the League Commission allow one egg per head per day for expectant and nursing mothers and one egg, or its equivalent, per day for children. On the assumption that the latter as well as the former have an average of one egg a day, then it is clear that, if the present total consumption is to remain unaltered, it would be impossible for the needs of these persons to be satisfied without reducing the supply of this valuable article of the diet available for the remainder of the population. To meet the requirements of the different sections of the population on the above assumptions, it would be necessary to increase the consumption from its present level to an estimated average of 3·9 eggs per head per week. The fact should be noted, however, that important though eggs be as articles of diet, there are other items in a mixed diet for children and adults, other than expectant mothers, which would complete an adequate diet, e.g. meat, fish, liver, etc. The selection of any of these alternatives may depend on economic considerations or personal preference, and we therefore do not feel justified in making any specific proposals in regard to the consumption of eggs by the population generally.

54. Sea Fish.—The League Commission recognises the importance of sea fish as a source of iodine. It is also a good source of protein of high nutritional value, of certain other minerals, and of the vitamins A and D. These vitamins are particularly abundant in fatty fish such as herring and mackerel. While it cannot be said that fish is indispensable for health, we have no hesitation in recommending the regular inclusion of some sea fish in the diet. The average national consumption of fish of all kinds is estimated at 8·9 ozs. net per head per week, but the consumption varies with income and is believed to be much less than this among the poorer sections of the population.

In the present state of knowledge we find it impossible to make any precise quantitative recommendation, but we suggest that the consumption should not fall below 8 or 9 ozs. net per head weekly.

55. *Potatoes*.—The League Commission states that “ An extended dietary use of the potato is recommended to replace part of the sugar and highly milled cereals in the ordinary diet. Potatoes provide extra vitamin C and more readily available calcium and phosphorus than are present in cereals. Potatoes also yield more iron and B vitamins than milled cereals.” We endorse this recommendation. The average consumption per head is in the region of 56 ozs. weekly at all income levels. We suggest that this consumption might be increased with advantage.

56. *Sugar*.—The Commission observes that the consumption of an excessive amount of sugar is to be condemned as it tends to lessen the proportion of protective foods consumed. Sugar is a rapidly utilisable source of energy but it does not possess any other food value, since it is devoid of any of the nutrients generally designated as constructive or protective. So far as is known, sugar is not detrimental to health when consumed in amounts ordinarily used for flavouring purposes, but it should not in practice be taken in large amounts in the fasting state. We agree that in these circumstances it dulls the appetite for more valuable foods and by leading to a deficient consumption of these it may influence nutrition adversely. It may also lead to a diminished consumption of the nutritionally more valuable foods by supplanting some of them as sources of energy. It would, however, be advantageous to know what amounts of sugar are adequate and what are excessive. There is no quantitative evidence on either of these points so that a precise statement about them cannot be made. It would appear from the available evidence that there has not been any appreciable increase in the national consumption of sugar since 1931.

57. *Energy and Protein Foods*.—In general, it may be said that where the energy content of the diet needs to be augmented it is preferable to increase the intake of bread rather than that of sugar, since bread contains some protein, appreciable quantities of important minerals and some vitamin B; and that where the diet is modified by increasing the protein intake in the form of milk, eggs, fish or meat any excess of energy that may result therefrom should be brought down to the standard requirements by reducing the intake of bread and sugar.

VI.—THE NUTRITIVE VALUE OF MILK AND MILK PRODUCTS.

58. *Milk*.—We attach such importance to milk that we prepared a special Memorandum, which was issued in March 1936 under the title of "The Nutritive Value of Milk," setting forth its value as a food, and for completeness we reproduce the Memorandum in Appendix II of this Report.

59. Milk is of such outstanding value that the consumption of a sufficient quantity of it may be regarded as the key to proper nutrition. Every one of the constituents of milk possesses high nutritive value and it is, therefore, most desirable that all of these should be utilised for human nutrition, more especially because the diets of many people are deficient in the nutrients supplied by milk and certain of its products. Moreover, cows' milk, the most complete food known, is elaborated from vegetable matter of little or no value for human nourishment, but this excellent food is not always put to the best use since large quantities of the so-called by-products of milk manufacture, particularly skimmed milk and buttermilk, are either fed to animals or wasted.

60. *Cream and Butter*.—Cream and butter are preparations containing higher concentrations of the fat and vitamins A and D than milk itself. It is on these constituents that the food value of cream and butter chiefly depends. As they are not complete foods the proper place for cream and butter is as items in a mixed diet in which they make good the deficiencies of other foods in fat and in vitamins A and D. The fats of milk are so constituted as to be especially valuable for human nutrition.

61. *Cheese*.—Cheese is manufactured from milk by straining off the coagulum, formed by previous treatment with rennet, and subjecting it to pressure. The milk is usually inoculated beforehand with certain bacteria, the propagation of which imparts to the finished product certain characteristic properties. Cheese, then, consists of milk, less the whey, which is drained off. It contains practically all the fat with its attendant vitamins A and D, the bulk of the protein and much of the calcium and phosphorus. Most of the other constituents of milk are separated with the whey. The nutritive properties of cheese, therefore, are principally those of the fat, protein, calcium, phosphorus and vitamins A and D of milk.

62. The chemical composition of an ordinary hard cheese is given in "The Nutritive Value of Milk" (Appendix II), but the composition varies within fairly wide limits according to the kind of cheese. For ordinary purposes, hard whole-milk cheese may be regarded as containing roughly equal parts of protein, fat and

water. Soft (e.g. packet) cheeses are often made by incorporating additional water into hard cheeses, and thus contain a higher proportion of water and correspondingly smaller proportions of protein and fat. Skimmed milk cheeses are made from various mixtures of whole-milk and skimmed milk; the amount of fat in skimmed milk cheese is naturally less than in whole-milk cheese and varies according to the proportion of skimmed milk used.

63. Cheese possesses some important advantages over liquid milk; it is much more concentrated and it can be kept for considerable periods. Cheese can be recommended as a very valuable food, either uncooked or as an ingredient in cooked dishes.

64. *Skimmed Milk.*—In the above-mentioned Memorandum brief reference was made to skimmed milk; but in view of the widespread belief that skimmed milk possesses little or no nutritive value we consider it desirable to discuss its properties in greater detail.

65. There is a fairly general impression that all the nourishment that is in the whole milk is removed with the fat. This is not so, for skimmed milk stands next to whole milk in the order of nutritive value of foods and differs from the latter only in so far as it contains very little of the fat with its attendant vitamins A and D. Except for these three nutrients, skimmed milk contains all those present in whole milk, or, in other words, all the remaining materials required for the nutrition of the body, viz., the protein, carbohydrate, vitamins B, C, and E, and inorganic elements. As with whole milk, however, a statement of the chemical constituents of skimmed milk gives an imperfect idea of its nutritive properties because it leaves unmentioned nutritionally important physico-chemical and biological characteristics. Unfortunately, little of this valuable food is available for sale in liquid form in this country.

66. The bone forming properties of milk are dependent on the calcium, phosphorus and vitamin D present in it. Dietary surveys have suggested that calcium is deficient in many diets, a defect which can be remedied as well by skimmed milk as by whole milk. Calcium, phosphorus and vitamin D are each essential for the formation of bone, but there is little vitamin D in skimmed milk. If, however, a diet contains enough cream or butter, the lack of this vitamin in the skimmed milk included in that diet would be of no consequence, and the skimmed milk would have the same physiological value as whole milk.

67. There is wide scope for the utilisation of skimmed milk in cooked foods such as puddings, bread and cakes; this is a very commendable practice which might be more extensively followed. Of the skimmed milk produced in this country, some

is dried and sold as such, some is incorporated in foods such as bread, cakes and confectionery, some is fed to farm animals and much is wasted. We are glad to note that the Milk Re-organisation Commission in its recent Report* deplored the wastage of this valuable food, and that it deprecated any action which would tend to make it less readily available for human consumption. In view of the fact that the total production of milk is less than the amount required for the proper nutrition of the population, we cannot regard with satisfaction the conditions governing the sale of milk products which render such a highly nutritious food as skimmed milk not readily available to the public.

68. In view of the cost of distributing liquid skimmed milk, we suggest that the dried state is the most convenient form for general use. Moreover, in this state it can be kept for long periods and it has the additional advantage of being safe. Dried skimmed milk is particularly suitable for puddings, bread, cakes and confectionery. In some districts where difficulties of distribution do not arise it might be found more convenient to supply skimmed milk in liquid form.

69. While recommending that as much as possible of the national production of skimmed milk should be consumed by the people, we desire to make it clear that it is not a proper food for babies under one year because of the absence of fat with its attendant vitamins. For all other members of the community it is little inferior to whole milk as an item in a mixed diet, if this contains adequate amounts of butter and other fats. We do not, of course, suggest that skimmed milk should replace whole milk in the national dietary. It should be used to supplement whole milk and not to replace it in the diet.

70. *Buttermilk*.—Most of what has been said above about the value of skimmed milk applies also to buttermilk, which differs from the former in that a variable amount of the milk sugar has been converted into lactic acid and the proteins are present in semi-coagulated form. These differences do not, however, detrimentally affect its food value to any appreciable extent, so that we may regard buttermilk as almost equal in nutritive value to skimmed milk. It is worthy of note that buttermilk is widely used in human diets in other countries, and also that it is extensively employed in the baking of home made bread in Ireland.

71. *Whey*.—The belief that whey is of no significant nutritional value is erroneous. Undoubtedly it is inferior to skimmed milk, cheese, or butter, but it is nevertheless sufficiently nutritious to warrant its use in human diets wherever it is available.

* Ministry of Agriculture and Fisheries Economic Series No. 44, page 279, H.M.S.O., 1936, price 1s. 0d. net.

Whey contains much of the sugar and minerals, and some of the proteins and vitamins of the milk from which it was derived, and, as an ingredient of foods made from cereals, it would go some way towards correcting the deficiencies in such foods.

72. *Safe Milk*.—This brief review of the nutritive properties of milk would be incomplete if reference were not made to the risks of contracting disease which may follow from the consumption of milk or skimmed milk in the raw state, and to the fact that milk can be made entirely safe by efficient pasteurisation or other heat treatment. We have drawn attention to this matter in "The Nutritive Value of Milk," (Appendix II, p. 37).

VII.—THE ASSESSMENT OF THE STATE OF NUTRITION.

73. We have endeavoured to obtain information as to the measurement of the state of nutrition as we considered that the correlation of the state of nutrition with the diet consumed would be of assistance to us in our inquiries.

74. We have had under review the various methods which have been tried or are in process of trial or have been suggested for the assessment of the nutritional state. We are unable to recommend any known method as reliable. So far as our present knowledge goes it would seem that the clinical method given in detail in Administrative Memorandum No. 124 of the Board of Education is the most promising, but the trial of this method has not been sufficiently prolonged to establish its reliability.

75. The League Commission has recommended that the assessment of the nutritional state of children should be a problem for further study and we are of opinion that the standardisation of tests for assessing the state of nutrition would be of assistance in connection with many of the problems of dietetics. We desire to record our view that research should be continued to establish, if possible, a reliable test or group of tests for the assessment of the state of nutrition.

76. We are gratified to learn that research work is being carried out by Local Medical Services in several parts of the country with the object of determining the value of various objective tests for the assessment of the state of nutrition.

VIII.—DIETARY IN POOR LAW INSTITUTIONS.

77. We have also been informed by the Ministry of Health that inquiries have been made to ascertain whether the recommendations contained in the Reports issued by the former Advisory Committee on Nutrition in 1932 on the "Criticism

and Improvement of Diets" and "Diets in Poor Law Children's Homes" have been generally adopted in Poor Law Institutions, and whether the changes have resulted in an improvement in the nutritional condition of the inmates. Although the dietaries in Poor Law Institutions do not require the approval of the Minister, the Ministry's General Inspectors, when visiting Institutions, continue to pay attention to the dietaries and have, on occasions, pointed out inadequacy by reference to those recommendations. The Reports were circulated to all Local Authorities and also to the voluntary homes certified for use by Public Assistance Authorities. Information has recently been specially obtained by the General Inspectors from each Public Assistance Authority regarding existing dietaries. We are informed that the great majority both of the County Councils and County Borough Councils have had the matter under consideration and have taken into account the recommendations referred to. A Medical Officer of the Ministry has visited a number of these Institutions, including Children's Homes, and has found the diet in many to be satisfactory and in others, when it has not been entirely satisfactory, suggestions for improvement have been made. His recommendations have been generally adopted.

IX.—FURTHER INVESTIGATIONS PROPOSED.

78. **Income Distribution.**—With a view to improving the statistical data as to the diet of the people, we have recommended (1) that the Ministry of Labour should take steps to obtain further information concerning the distribution of working-class earnings, and (2) that the Registrar-General for England and Wales should be asked to carry out an inquiry on a large scale into the constitution of families by age, sex, occupation and locality and, by means of estimates of occupational incomes to be made on our behalf by an independent statistician, into the distribution of family incomes. An inquiry on the lines mentioned in (2) above is already proceeding in Scotland at our suggestion. If these further investigations are carried out it should be possible to obtain a more reliable estimate of the distribution of the population in income groups than has hitherto been possible, and the results may be found to be of use in fields other than the purely nutritional with which we are concerned.

79. **Family Budgets.**—We have also passed a resolution that, having regard to the small amount of information at present available as to the actual consumption of food by different sections of the population, and in view of the importance of the issues involved, we consider it essential that early steps should be taken to collect family budgets and to undertake dietary surveys on a comprehensive scale, and that the appropriate Departments should co-operate in devising the machinery and

technique for the purpose. We were influenced in coming to this conclusion by the view of our Statistical Sub-Committee that the budget and dietary material used by the Market Supply Committee, while it was the best available at the moment, could not be expected to yield more than a rough indication of the variations of consumption and expenditure throughout the whole population.

80. It has since been announced that the Ministry of Labour will shortly undertake a family budget inquiry to provide the material required for a revision of the basis of the cost-of-living index. It is expected that the inquiry will provide much of the information which we require as to the quantities of the various kinds of food obtained by the families from whom the budgets are collected.

81. We recognise that even this larger collection of family budgets could only give rough indications of the way in which total food consumption is distributed among the whole population. For example, it is difficult to obtain from family budget inquiries particulars of food consumed away from home and family budgets do not, of course, cover food consumed by residents in hotels and institutions. On the other hand, family budgets supply essential data for estimating (1) the average ratio of food expenditure to total expenditure at different income levels and (2) the way in which expenditure on food is likely to be allocated between particular foods having regard to type of family, occupation, income group and district.

82. **Dietary Surveys.**—In order that full use may be made of this information for dietetic purposes it is necessary to know what is the proportion of domestic wastage for each kind of food. We are informed that some figures as to this will shortly be available as a result of the dietary surveys undertaken by local authorities in some urban areas in England. We think it desirable that these should be supplemented by figures for other areas, and we have therefore also recommended that exact studies of the diets of several hundred families should be carried out in England and Wales, principally in rural areas, and in Scotland.

X.—SUMMARY.

i. Our terms of reference involve a more comprehensive survey of the food supplies, diets, and state of nutrition of the population than any hitherto attempted in this, or any other, country (paras. 3-6).

ii. During the past quarter of a century increasing importance has been attached to positive measures for promoting health. Recent advances in the science of nutrition have shown that improvements in health and physique can be attained by

consumption of adequate amounts of the protective foods. This is especially important for mothers and children (paras. 11-16).

iii. The progressive application of this knowledge and the concurrent rise in the standard of living have contributed to the general improvement in health, and to the marked declines in the rates of mortality and in the incidence of deficiency diseases such as rickets. The greater availability of certain foods of special value for nutrition, such as butter, cheese, and fruit, and the increased attention given to the nutrition of mothers and children have also played a part in this trend (paras. 17 and 18).

iv. There is, however, much room for further improvement in the health and physique of the nation, and the more extensive application of recent discoveries in nutrition should result in new and higher levels of physical well-being (para. 19).

v. The national dietary contains sufficient energy-giving foods for the whole population. We conclude that all, except a relatively small fraction of the population, are obtaining the full amount of calories they require (para. 23 (a)).

vi. The consumption of fat has largely increased in recent years and this suggests that there is no aggregate deficiency in the national dietary; but there is some deficiency in the diets of the very poorest (para. 23 (b)).

vii. Consideration of the national food supply does not reveal a shortage of total protein. But all protein is not of the same nutritional value; the consumption of protein of high nutritional value (meat, dairy products and fish) rises with income. Although there is no recognised standard requirement of animal protein, it is probable that there is some shortage of this constituent in the diets of the poorest section of the community (para. 23 (c)).

viii. We have computed that the allowances suggested in the preliminary report of the League Commission (December, 1935), and adopted in our Memorandum on "The Nutritive Value of Milk", are equivalent to an average consumption of milk per head of about seven-eighths of a pint per day. This level would represent a doubling of present consumption of liquid milk. The consumption of milk in all forms, which is about half a pint per head daily, is only 60 per cent. of the suggested amount (paras. 23 (d), 38 and 52).

ix. The average daily consumption of milk per head should be about two pints for expectant and nursing mothers, from one to two pints for children and not less than half a pint for the rest of the population (para. 24).

x. From the health standpoint there is no other single measure which would do more to improve the health, development and resistance to disease of the rising generation than a

largely increased consumption of safe milk, especially by mothers, children and adolescents, and we hope that in dealing with the problem of milk now and in the future, the primary objective of the State will be to ensure that a supply of safe milk, to the amount we have recommended above, is brought within the purchasing power of the poorest. We deplore the fact that there is a deficiency of milk in the diet of large sections of the population (paras. 25-29).

xi. It is very probable that the national consumption of fruit and vegetables is below the requirements for optimum nutrition (para. 23 (e)).

xii. Estimates of total food supplies in 1934-5 have been obtained from the Departments concerned. The main elements of uncertainty in these figures are the estimates made for food produced in private gardens and allotments, and food consumed by farm households (paras. 30 and 31).

xiii. Comparison with previous estimates made by Sir Alfred Flux for 1909-13 and 1924-8 shows that there has been a general improvement in the national diet since before the war, but the national average consumption of some of the protective foods has remained low, that of milk being practically stationary since pre-war years (paras. 22 and 36-39).

xiv. The figures of the total food supplies given in this Report are gross figures and take no account of wastage in distribution and in the home (para. 34).

xv. An investigation is being made with a view to obtaining improved data as to the nutritive equivalents of different varieties of meat. Preliminary results show that there are a higher proportion of protein and a lower proportion of fat in the bacon and ham supply than before the war (para. 41).

xvi. The broad picture prepared by the Market Supply Committee of the probable variation in consumption of particular foods, can only be a rough approximation in view of the incompleteness of the data, but in spite of the uncertainty and slender foundation of many of the estimates, the conclusions as to the broad trend of consumption of the different articles of food over the income groups appear to us likely to be in accordance with the facts (paras. 42-45).

xvii. We have examined, and, except for some minor reservations generally approve of all the recommendations set forth in the report of the Technical Commission of the League of Nations on the Physiological Bases of Nutrition. The Commission has set up a new and high level of nutrition which we have adopted (paras. 46-51).

xviii. Sea fish is particularly valuable as a source of good protein, of iodine and other minerals. Herring and mackerel are especially rich in vitamins A and D (para. 54).

xix. The present average consumption of potatoes is about 56 ozs. per head weekly. We recommend that the consumption should be increased, replacing some of the sugar and highly-milled cereals in ordinary diets (para. 55).

xx. We regard the consumption of a sufficient quantity of milk as the key to proper nutrition and we draw attention to our Memorandum "The Nutritive Value of Milk" which is reproduced as Appendix II to this Report (para. 58).

xxi. We deal with the nutritive value of cream, butter and cheese, and draw special attention to the nutritive value of the so-called by-products of milk manufacture, namely skimmed milk, buttermilk and whey. We are of opinion that as much as possible of these very nutritious products should be made available for human consumption, because the satisfaction of the nutritional needs of the people should be the predominant consideration concerning the disposal of these products (paras. 60-71).

xxii. We are unable to recommend any method of assessing the state of nutrition as reliable and we consider that research should be continued with a view to establishing if possible a reliable test or group of tests (paras. 73-76).

xxiii. We are informed that efforts are being made to remodel diets in Poor Law Institutions where necessary, so as to put into practice modern knowledge of the science of nutrition, a valuable step in this direction having been taken by the publication of the reports of the earlier Advisory Committee on Nutrition (para. 77).

xxiv. We propose the following further investigations:—

- (a) Distribution of the National Income by Income Groups.
- (b) Family Budget Material.
- (c) Quantitative Dietary Studies (paras. 78-82).

XI.—ACKNOWLEDGMENTS.

We take this opportunity of recording our special indebtedness to the Market Supply Committee for its most valuable co-operation in the statistical aspects of our inquiries and to its staff who have carried out much statistical work on our behalf.

We also wish to record our appreciation of the very helpful advice given to us by other persons who have been co-opted as members of some of the Sub-Committees for the consideration of special problems, and to express our thanks to them and to others who have assisted us in our deliberations and inquiries. Our thanks are also due to the Health Organisation of the League of Nations, by whose courtesy the extract from the

Report on the Physiological Bases of Nutrition has been reproduced as Appendix III.

In conclusion we desire to record our cordial appreciation of the valuable services rendered to us by our Secretary, Mr. W. J. Peete, and our Medical Secretary, Dr. H. E. Magee, in their respective capacities.

Mr. Peete has carried out the arduous duties as a Secretary including the preparation of this report with great zeal and efficiency, and Dr. Magee with his intimate knowledge of the subject, especially in the preparation of a number of technical memoranda, has been of immense assistance to us in our consideration of the problems with which we have been faced.

It is with deep regret that we have to record the death in August, 1936, of Dr. A. M. Chalmers Watson, C.B.E. Her extensive knowledge and experience were of the greatest value to us in the consideration of the problem of nutrition generally, as well as in its technical aspects.

We have the honour to be,

Sirs,

Your obedient Servants,

LUKE (Chairman).

ELEANOR BARTON.

J. N. BECKETT.

GEORGE F. BUCHAN.

E. P. CATHCART.

R. R. ENFIELD.

J. ALISON GLOVER.

J. M. HAMILL.

A. BRADFORD HILL.

F. GOWLAND HOPKINS.

DONALD HUNTER.

E. M. H. LLOYD.

E. MELLANBY.

JOHN ORR.

RUTH PYBUS.

E. C. RAMSBOTTOM.

J. M. VALLANCE.

T. W. WADE.

J. R. WILLIS.

E. H. T. WILTSHIRE.

W. J. PEETE,

Secretary.

H. E. MAGEE,

Medical Secretary.

5th March, 1937.

APPENDIX I.

Foodstuffs for Human Consumption: United Kingdom.

Average of the two years 1934 and 1935.

(Products manufactured from imported materials, e.g. flour, margarine and chocolate are treated as imported).

Commodity.	Home Production.	Per cent. of total supply.	Imports less total exports.	Total Quantities available for consumption.
<i>Cereals—</i>	ooo tons.	Per cent.	ooo tons.	ooo tons.
Wheat flour	500	11·9	3,693	4,123 (a)
Barley meal	25	45·5	30	55
Oat products	50	50·0	50	100
Tapioca, Sago, etc.	—	—	50	50
Rice	—	—	57	57
Other cereals (e.g. macaroni, etc.)	—	—	42	42
Total cereals	575	12·8	3,922	4,427(a)
<i>Meat—</i>				
Beef and Veal (b)	635	52·8	566	1,201
Mutton and Lamb (b)	255	43·0	339	594
Pork (b)	217	79·2	57	274
Bacon and Ham (b)	153	27·5	404	557
Other meat	107	41·3	152	259
Poultry and Game	86	79·6	22	108
Rabbits	50	72·4	19	69
Total meat	1,503	49·1	1,559	3,062
<i>Fish—</i>				
Herrings	128(c)	100·0	—	128
Other fish, fresh or cured	702(d)	94·2	43	745
Shell fish (f)	8	72·7	3	11
Canned fish	(e)	—	69	69
Total fish	838	88·0	115	953
<i>Milk and Dairy Produce—</i>				
Milk, fresh (mln. gls.)	910	100·0	—	910
„ condensed whole	92	92·0	8	100
„ „ skimmed	53	41·4	75	128
„ powder	13	52·0	12	25
Butter	53	10·0	476	529
Cheese	63	31·0	140	203
Cream	33	89·3	4	37
Lard	19	10·0	181(g)	200
Margarine	—	—	169	169
Eggs in shell (mlns.)	4,700	67·1	2,307	7,007
(„ „) (thous.tons)	(262)	67·1	(128)	(390)
Eggs, liquid, dried and frozen	—	—	40	40

Commodity.	Home Production.	Per cent. of total supply.	Imports less total exports.	Total Quantities available for consumption.
<i>Fruit—</i>	ooo tons.	Per cent.	ooo tons.	ooo tons.
Apples	315(<i>h</i>)	49·9	316	631
Oranges	—	—	499	499
Bananas	—	—	324	324
Other fresh fruit ...	230(<i>h</i>)	43·6	298	528
Nuts	5	7·2	64	69
Dried fruit	—	—	175	175
Canned fruit	(<i>j</i>)	—	192	192
Desiccated coconut ...	—	—	14	14
Total fruit	550(<i>h</i>)	22·6	1,882	2,432
Fruit Pulp	—	—	28	28
<i>Vegetables—</i>				
Potatoes	4,500(<i>h</i>)	97·2	129	4,629
Dried beans, peas and lentils	15	10·2	132	147
Green lentils	200(<i>h</i>)	99·5	1	201
Other vegetables (including tomatoes and rhubarb)	1,600(<i>h</i>)	78·8	432	2,032
Preserved vegetables ...	(<i>j</i>)	—	45	45
<i>Sugar, etc.—</i>				
Sugar (in terms of refined)	530	27·9	1,368	1,898
Molasses	—	—	32	32
Glucose	—	—	24	24
Honey	1	25·0	3	4
<i>Beverages—</i>				
Tea	—	—	195	195
Coffee	—	—	15	15
Cocoa, Chocolate powder and Cocoa products ...	—	—	68	68

(a) Excludes 70,000 tons of wheat flour estimated to have been used for industrial purposes which cannot be distributed between home production and imports.

(b) Tinned meat and edible offals included in "other meat."

(c) Net landings after allowing for net exports of fresh or cured herrings and making further allowance for weight of containers of cured herrings.

(d) No estimate for fresh water fish has yet been made.

(e) Included in fish above.

(f) Estimated edible portion only.

(g) Includes 65,000 tons of imitation lard manufactured in the United Kingdom from imported raw materials.

(h) Includes allowance for allotments and private gardens.

(j) Included in fresh fruit or vegetables.

APPENDIX II.

THE NUTRITIVE VALUE OF MILK.

A food which contains all the materials essential for growth and maintenance of life in a form ready for utilisation by the body is obviously of high value. Milk alone is the food which in itself nearly fulfils these conditions, being elaborated by the mammalian mother as the sole nutriment of her offspring during the period of most rapid growth.

Mothers' milk is the ideal food for the young of the same species, but it is not quite ideal for the young of another species. Next to milk of the same species that of another is the best food for the nutrition of young mammals, since the composition of the bodies of mammals and the nature of their living processes are fundamentally the same. The milk of any species of animal, provided it is palatable, is also an eminently suitable food for human beings, especially during growth, pregnancy and lactation. Cows' milk is usually consumed by human beings, but there is no biological reason why that of other animals should not also be used.

THE COMPOSITION OF MILK.

The chemical composition of cows' milk is shown in the first line of Table I. It contains the energy-giving nutrients, protein, fat and carbohydrate; all the known essential vitamins; calcium, phosphorus, iron, sulphur, iodine, magnesium, potassium, sodium, chlorine and copper, some of the physiological roles of which are known; and a number of other elements, present only in minute amounts, such as manganese, zinc, and fluorine, the exact functions of which are not fully understood, but which would seem to be as necessary for normal nutrition as any of the other constituents. Even if it were possible to state the chemical composition of milk in full a very imperfect idea of its nutritive value would be obtained, because it would leave unmentioned many important physico-chemical and biological properties on which its high nutritive value largely depends. For example, the physico-chemical states of its constituents make for easy digestion and assimilation; the relationship of the different constituents to one another ensures normality of bodily function; the nature of its protein and of its mineral elements, notably calcium and phosphorus, and its high content of other inorganic elements and vitamins make for satisfactory growth and give it a very high value as a protection against disease.

NUTRITIVE VALUE.

The fact that milk is a valuable human food, particularly when new tissues are being formed, has been recognised from the earliest times. Within recent years much experimental evidence has been brought forward, which has shown that cows' milk is the most valuable food known for the promotion of growth and health in children. Some of these investigations, like those of Mann in this country and McCollum and others in the United States, have been carried out under carefully controlled conditions in residential institutions. Others, like those of Orr and Leighton, and Leighton and McKinlay in this country and of other workers in New Zealand, France and Japan, have been carried out on large numbers of school children living at home. The general conclusion to be drawn from these investigations without exception is that milk is an essential item in the diets of children for optimum growth, physique and the maintenance of health. Many other investigations have been carried out in institutions and elsewhere in this country by M. McIlanby and her colleagues, and in the United States by Davies, Bunting and others, the results of which have shown that milk is all-important for the development of normal teeth resistant to dental caries. From the results of these and many other experiments too numerous to

mention, on man and animals, it can be predicted that important beneficial effects would result from an increase in the consumption of milk above that at present prevailing in this country. The present consumption of liquid milk is somewhere in the region of 0.4 pint per head per day, on the average, but the information obtained from dietary surveys has shown that the consumption in very many families is well below this figure. There can be little doubt from the experimental evidence obtained that an increase in the average consumption of milk to about one pint per head per day would result in the improvement of the general health of the community, especially in the case of children, in whom it would secure better bone formation and improvement in stature and physique. It would diminish the incidence of disease, including rickets, and increase resistance to dental caries.

MILK AS AN ARTICLE OF DIET.

Milk is in itself a well balanced mixed diet. Its few disadvantages, which vary with the age of the person for whom it is intended, are easily overcome. All babies should be brought up on their mother's milk, but after breast feeding ceases, although cows' milk ought to form the bulk of the diet, this should be supplemented with iron, vitamins D and C, preferably given in the form of natural foods, such as egg-yolk, orange juice and cod-liver oil. For children, adolescents and adults a diet of milk alone is undesirable because it is deficient in energy-giving constituents relative to its bulk. For these it should be regarded as an important item in a mixed diet and not as a complete food; but on account of its growth-promoting properties it should form a larger proportion of the diet of children and adolescents than of that of adults. The expectant mother has to elaborate from her food the materials necessary for the growth of her offspring, while the nursing mother has to secrete milk to serve as the only food of her infant for at least six months. The milk requirements of the expectant or nursing mother are of a similar order to those of the growing child.

AMOUNTS OF MILK REQUIRED.

The desirable amount of milk for children would seem from investigations of Sherman, Daniels and others to be from one to two pints per day, and for expectant and nursing mothers according to Mellanby and others it is about two pints per day. In regard to other adults there is a consensus of opinion that enough milk or milk products should be consumed to secure a sufficiency of calcium. Dietary surveys have shown that calcium and animal protein are very frequently deficient in diets in this country, but while deficiencies of animal protein can be made good by meat, fish or eggs, the best and most convenient means of assuring a sufficiency of calcium is by including in the diet an adequate amount of milk, which would of course enrich the diet with all the other valuable nutrients, including protein, present in milk. It would seem that a minimum of 0.5 pint of milk daily is desirable for an adult.

THE EFFECT OF HEAT ON MILK.

The effects of heat on the nutritive value of milk for animals have been extensively studied, but the few human experiments that have been done have not shown that heat significantly lowers the food value of milk for man. This does not necessarily mean that heated milk is equal in all respects to raw milk, since such a conclusion could only be drawn if we knew all there is to be known about human nutrition and about the nutritive properties of milk, and this is far from being the case. So far as is known, the only significant changes effected in the composition of milk by heat are a partial loss of vitamin C and possibly of iodine. The amount of vitamin C in raw milk is in any case small and even in raw milk some loss usually occurs in course of distribution. These deficiencies

can be made good in the diet of babies fed exclusively on cows' milk by the addition of fruit or vegetable juice and cod-liver oil, and in the diets of children and adults by the other items in a good mixed diet which should always contain potatoes or other vegetables or fresh fruit and some sea fish. It is, therefore, reasonable to assume that heated or dried milk or milk incorporated in other cooked articles of diet such as bread and puddings retains most of the nutritional properties of raw milk.

The heating of milk, moreover, has important advantages in rendering it safe for consumption.

It is an unfortunate fact that milk is a medium through which disease may be conveyed to man. Milk is liable to become contaminated with the organisms of disease in two ways: (1) organisms may be transferred from a diseased cow to its milk and through the milk to man, and (2) organisms may be introduced into the milk from the milkers or other persons who handle and deal with it, or from infected utensils. These organisms, however, can be destroyed and the milk rendered safe for consumption by suitable heat treatment such as by efficient pasteurisation or boiling.

The ideal is milk from perfectly healthy cows, but herds in which all the cows are perfectly healthy are at present relatively few. Where such milk is not available the milk should be pasteurised or boiled before use.

THE EFFECT OF MANUFACTURING PROCESSES ON MILK.

When milk is submitted to processes resulting in the extraction of any of its solid constituents the nutritive value of any of the resulting fractions is, of course, lower than that of the whole of the original milk. The relative values of milk and its various derivatives are stated in Tables I and II.

The chief difference in nutritive value between separated milk and whole milk is due to the smaller amount of fat which the former contains. This defect of separated milk can be remedied by the inclusion of suitable fats in the diet. Furthermore, in an experiment carried out by Orr and his colleagues in which separated milk was given as a supplement to the ordinary home diets of school children it was found that separated milk was of high nutritive value.

Cream and butter are very valuable foods, but they cannot in any sense be regarded as complete foods because, for all practical purposes, their food value depends entirely on their content of easily digested and assimilated fat, the growth-promoting and protective vitamin A and variable but not very large amounts of the anti-rachitic vitamin D. They are, therefore, incomplete foods and in this respect compare very unfavourably with whole or even separated milk. Cream or butter is considered by many to be by far the most valuable constituent of milk: this is not the case, for cream or butter contains only three of the essential dietary constituents whereas whole milk contains all of them and separated milk the great bulk of them.

The high nutritive value of cheese can be seen by comparing it with its nearest equivalent, dried milk. (See Table I.) The most marked difference is that the carbohydrate content of dried milk is about 11 times that of cheese. Cheese contains relatively less of the B and C vitamins and of certain minerals than whole milk. To this extent, at least, cheese is inferior in nutritive value to whole liquid milk.

The nutritive value of whey is considerable, as can be seen from Tables I and II. It is relatively rich in sugar and mineral elements and also contains significant amounts of protein and the B and C vitamins. It is, like butter or cream, an imperfect food and its proper place in a diet, like that of butter or cream, would be to compensate for corresponding deficiencies in other imperfect foods. Thus whey would add considerably to the nutritional value of a diet containing cereals and cereal products.

TABLE I.
Approximate Composition of Milk and Milk Products.

Food	Protein	Fat	Carbo- hydrate	Cal- cium	Phos- phorus	Iron	Sulphur	Mag- nesium	Potas- sium	Sodium	Chlorine	Calories
Whole milk (grams per 100 ml.).	3.3	3.6	4.8	0.120	0.093	0.00024	0.034	0.012	0.143	0.051	0.106	378 per pt.
Separated milk (grams per 100 ml.).	3.4	0.3	5.0	0.122	0.096	0.00025	0.035	0.012	0.149	0.052	0.110	206 per pt.
Whey (grams per 100 ml.).	0.9	0.3	5.1	0.044	0.035	?	0.009	0.008	0.157	0.038	0.119	150 per pt.
Cream* (grams per 100 grams).	1.8	50.0	2.7	0.067	0.052	0.00022	0.019	0.007	0.080	0.028	0.059	2,123 per lb.
Butter (grams per 100 grams).	0.6	83.0	0.2	0.015	0.017	0.00020	0.010	0.001	0.014	—	—	3,281 per lb.
Cheese (grams per 100 grams).	25.7	35.0	3.1	0.931	0.683	0.00130	0.263	0.037	0.089	—	—	2,011 per lb.
Dried milk (grams per 100 grams).	23.8	26.0	34.1	0.840	0.651	0.00168	0.238	0.084	1.000	0.357	0.742	2,112 per lb.

* Cream may contain any proportion of fat from about 20 or 25 per cent. upwards. The figure of 50 per cent. given in the table is generally recognised as the approximate proportion for thick cream.

TABLE II.

*Amounts supplied by Daily helpings in common use.
(Whey included for comparison).*

Food.	Quantity.	Calories.	Protein grams.	Calcium grams.	Phosphorus grams.	Iron grams.	Sulphur grams.
Whole milk	1 pint	378	18.70	0.682	0.528	0.001363	0.193
Separated milk	1 pint	206	19.32	0.693	0.545	0.001420	0.199
Cream	½ oz.	33	0.13	0.005	0.004	0.000016	0.001
Butter	1 oz.	205	0.17	0.004	0.005	0.000057	0.003
Cheese	½ oz.	63	3.65	0.132	0.097	0.000185	0.037
Whey	1 pint	150	5.00	0.250	0.200	?	0.031

Note.—It will be observed in this Table and in Table I that separated milk contains rather more of certain constituents than whole milk. To avoid possible misconception it should be pointed out that in the separation of the cream from whole milk, all the constituents, with the exception of fat, remain in the separated milk, practically in their entirety. Hence in one pint of separated milk the amounts of constituents other than fat are greater than those present in one pint of whole milk.

APPENDIX III.

Extract from the Report on the Physiological Bases of Nutrition drawn up by the Technical Commission of the Health Committee of the League of Nations.

PART I.

ENERGY, PROTEIN AND FAT REQUIREMENTS.

All the figures on which the Commission has agreed are average values and it is essential that they should be interpreted in the light of this fact.

1. Calorie Requirements.

(a) An adult, male or female, living an ordinary everyday life in a temperate climate and not engaged in manual work is taken as the basis on which the needs of other age-groups are reckoned. An allowance of 2,400 calories net* per day is considered adequate to meet the requirements of such an individual.

(b) The following supplements for muscular activity should be added to the basic requirements in (a): †

Light work	...	up to	75 calories	per hour of work.
Moderate work	...	"	75-150	" " "
Hard work	...	"	150-300	" " "
Very hard work	...	"	300 calories and upwards	per hour of work.

(c) The energy requirements for other ages and for mothers can be obtained from the following table of coefficients:

Age (years).	Coefficient.	Calories.
1-2	0.35	840
2-3	0.42	1,000
3-5	0.5	1,200
5-7	0.6	1,440
7-9	0.7	1,680
9-11	0.8	1,920
11-12	0.9	2,160
12-15‡	1.0	2,400
15 and upwards	1.0	2,400

* The term "net calories" refers to the amount of energy available from the food actually assimilated.

† For statistical purposes, to be comparable with previously adopted standards, 600 calories per day may be taken as an average supplement for muscular work.

‡ The needs of puberty are covered by giving the child of 12-15 years a calorie allowance corresponding to a coefficient of 1, with appropriate supplements for muscular activity and a protein allowance of 2.5 grammes per kilogramme of bodyweight.

The muscular activities characteristic of every healthy child and adolescent necessitate additions to the basic requirements shown in (c). It is suggested that the activities of children of both sexes from 5-11 years be considered as equivalent to light work, of boys from 11-15 years as moderate work and of girls from 11-15 upwards as light work.

Women :				<i>Coefficient.</i>	<i>Calories.</i>
Pregnant	...	...	...	1.0	2,400
Nursing	...	...	...	1.25	3,000

Allowance must also be made for women engaged in household duties, whether pregnant or not; these have to be reckoned as equivalent to light work for eight hours daily.

The requirements for babies under 1 year are difficult to specify except in terms of body-weight; the following allowances are considered adequate:

<i>Age (months).</i>					<i>Calories per kilogramme of body-weight.</i>
0-6	...	...	...	...	100
6-12	...	...	...	...	90

2. Protein Requirements.

In practice, the protein intake for all adults should not fall below 1 gramme of protein per kilogramme of body-weight. The protein should be derived from a variety of sources, and it is desirable that a part of the protein should be of animal origin.

During growth, pregnancy and lactation, some animal protein is essential, and in the growing period it should form a large proportion of the total protein.

The following allowances of total protein are recommended:

<i>Age (years).</i>					<i>Grammes per kilogramme of body-weight.</i>
1-3	...	...	...	...	3.5
3-5	...	...	...	...	3.0
5-12	...	...	...	...	2.5
12-15*	...	...	...	...	2.5*
15-17	...	...	...	...	2.0
17-21	...	...	...	...	1.5
21 and upwards	...	...	...	...	1.0

Women :

Pregnant—0-3 months	...	...	...	...	1.0
4-9 "	...	...	...	...	1.5
Nursing	...	...	...	...	2.0†

* See footnote (†) to paragraph 1 (c) above.

† See footnote (*) on page 20.

3. Fat Requirements.

Fat must be a constituent of the normal diet, but the data at present available do not suffice to permit a precise statement of the quantity required. The high content of vitamins A and/or D in certain fats justifies their use in liberal amounts.*

4. The Influence of Climate on Dietary Requirements.

In cold climates, the energy-content of the diet may need to be increased. Where climatic conditions or social customs do not permit of exposure to sunshine, vitamin D should be supplied in the diet.

PART II.

MINERAL AND VITAMIN REQUIREMENTS.

5. The Commission recognises the fact that the deficiencies of modern diets are usually in the *protective foods* (foods rich in minerals and vitamins) rather than in more strictly *energy-bearing foods* (rich in calories).

The term *protective food* denotes a foodstuff which is especially rich in those nutrient principles, "good" protein, vitamins or minerals, in which the principal foods of any geographic area are deficient.

Thus, e.g., in the United States of America—where the chief constituents of the daily diet are usually white bread and other foods made from white flour, sugar and muscle meats—milk and the leafy vegetables form the most important protective foods.

In other regions where the protein content of the diet is either too low or of poor quality (e.g., Asiatic diets consisting chiefly of polished rice or soja bean, with a small quota of green vegetables), meat would provide a highly valuable protective food.

In yet other areas where the diet consists almost exclusively of cooked or dry foods, fresh fruits and/or vegetables might be the most important protective food.

Among the protective foods are, first and most important, milk and milk products (including butter), eggs and glandular tissues; then green-leaf vegetables, fruit, fat, fish and meat (muscle). Among the energy-bearing foods of little or no protective power are sugar, milled cereals and certain fats.

Of energy-giving foods, unmilled cereals are not rich in protective nutrients and the more they are refined the less is their protective power. Many fats, especially when refined, possess little or no protective constituents. Refined sugar is of value only as a source of energy; it is entirely devoid of minerals and vitamins. The increasing habit in certain countries of large sugar consumption tends to lessen the amount of protective foods in the diet and is to be regarded with concern.

In cases where energy values are equal, protective foods should always be preferred.

* See footnote (*) on page 20.

6. *Requirements of Pregnancy and Lactation.*

The Commission has attempted to define the quantitative needs of protective foods for perfect nutrition in terms of the requirements for the pregnant and nursing woman. She should be regarded as the member of the population needing the greatest "protection" in order to ensure adequate physical endowment for the child at birth and optimum nutrition during infancy.

The greatest difficulty in arranging such a diet is to provide adequate calcium, phosphorus, iron and vitamins B₁, B₂, C and D.

7. Milk, whole or skimmed, is a rich source of calcium salts and phosphates and of vitamin B₂, also a good source of vitamin B₁; milk fat is an excellent source of vitamin A. Eggs contain vitamins A, B₁, B₂, and D and are rich in iron. The proteins of milk and eggs are not only themselves of the highest nutritive value, but also improve the utilisation of the protein contained in cereals and vegetables. Milk has an additional advantage in that the abundance and availability of its calcium salts and phosphates enhance the effect of any vitamin D derived from other articles of diet or from sunshine. Milk, although itself poor in iron, renders more effective the iron contained in the diet.

8. Ordinary diets are usually inadequate in vitamin D and, except in sunny seasons and sunny countries, a small daily ration of cod-liver oil or other fish-liver oil rich in vitamin D is to be recommended in the diet of the pregnant and nursing mother and in that of the growing child. Fish-liver oils are also the richest known natural sources of vitamin A and are important sources of iodine. In goitrous regions, where sea-fish are not available, the provision of extra iodine in the form of iodised salt or in some other way is recommended.

9. An extended dietary use of the potato is recommended to replace part of the sugar and highly milled cereals in the ordinary diet. Potatoes provide extra vitamin C and more readily available calcium and phosphorus than are present in cereals. Potatoes also yield more iron and B vitamins than milled cereals.

The above paragraph applies to countries where potatoes are abundant, but it is of general application, due account being taken of local resources.

10. *Requirements of Other Adults and Children.*

In Tables I-VI, some simple schedules have been prepared to show how a selection of common protective foods will ensure safe intakes of the necessary protein, minerals and vitamins for a pregnant and nursing woman and for infants and children of ages up to 14 years. These are based on investigations made in the United Kingdom, the United States and Scandinavian countries, and are put forward to indicate how the dietary principles set forth in this report could be put into practice where these foods are available. In every locality, it will be necessary to discover the selection of food materials which is best adapted to national dietary habits and resources, and at the same time conforms to the needs of pregnancy, lactation and growth.

No attempt is made to lay down a detailed dietary programme, or to suggest the wide choice of protective and energy-yielding foods, whose selection will be influenced by availability, appetite and economic cost. Attention should, however, be directed to the value of the lightly milled cereals as a further source of iron and vitamin B₁, and of butter in preference to other common fats, because of its rich content of vitamin A.

The protective foods in Table I are arranged to yield approximately 1,400 calories without inclusion of cereals, fats or sugar; these can be added as required to satisfy the energy requirements of any individual. For adults other than the pregnant and nursing woman, the amount of protective foods might be reduced, if necessary, for economic reasons. For growing children, however, the maintenance of a high proportion of protective foods should be the aim.

In Tables II-VI, schedules are drawn up on the above basis for age-groups 0-1, 1-2, 2-3, 3-5, 5-7 and 12-14 years. Since the rate of growth of a child decreases with advancing age, it will be noted that the amounts of protective foods are not greatly increased for the older groups.

II. General Recommendations.

A. Although a *simplified* diet may be so constituted from a few protective foods as to be satisfactory, it is a general principle that *variety in diet* tends to safety, provided it contains a sufficiency of the protective types of food materials.

B. *White flour* in the process of milling is deprived of important nutritive elements. Its use should be decreased and partial substitution by *lightly milled cereals* and especially by *potatoes* is recommended. The consumption of an excessive amount of sugar is to be condemned, as it tends to lessen the proportion of protective foods.

C. Milk should form a conspicuous element of the diet at all ages. The Commission commends the tendency manifested in some countries to increase the daily intake up to one litre per day for pregnant and nursing women, as well as to provide an abundant supply for infants, children of all ages and adolescents. The practice of providing milk either free or at a reduced price to these groups is highly recommended.

The ration of milk indicated in Tables I-VI provides from 100-75 per cent. of the total calories during the first years of life, decreasing to about 50 per cent. at 3-5 years and to about 25 per cent. at the age of puberty. For the older groups, some portion of the milk or meat may be replaced by cheese.

The Commission desires to draw attention to the high nutritive value of *skimmed and separated milk*, which, although deprived of its vitamin A through removal of the fat, retains the protein, the B and C vitamins, the calcium and other mineral elements. The Commission deplors the large wastage in many countries of this valuable food.

D. Fresh vegetables and/or fruit should always be constituents of the normal mixed diet. Adequate provision of the vitamins other than vitamin D can be readily accomplished by inclusion in the diet of optimum amounts of protective foods.

E. The Commission emphasises the need for provision of *extra vitamin D*, wherever and whenever sunshine is not abundant, especially in the period of growth and during pregnancy. Where the appropriate rich foods are not available, only such *vitamin preparations as are officially controlled and approved* should be permitted. The indiscriminate use of irradiated foods, except in the case of milk, is deprecated.*

* See footnote (*) on page 20.

12. *Problems recommended for Further Study.*

- A. Assessment of the nutritional state of children.
- B. Nutritive food requirements during the first year of life.
- C. Minimum vitamin and mineral requirements.
- D. Minimum fat requirements.
- E. The nutritive and "supplementary" values of the different protein-containing foods, to determine to what extent and in what forms animal protein is necessary for growth and health.
- F. The relative nutritive value of different cereals according to the degree of milling.
- G. The extent to which the increasing consumption of sugar is detrimental to health.
- H. Influence of climate on food requirements.
- I. The extent to which diets in common use fall below the standards recommended in this report.
- J. The optimum amounts of milk required at different ages.

DIETARY SCHEME FOR THE

A. Protective Foods.

Food.	Amount.	Protein.	Calcium.	Phosphorus	Iron.	Iodine.
	Grammes.				Milligrammes.	
Milk	1,000	32	1.2	0.9	2.4	0.02-0.05
Meat (or fish or poultry) ...	120(a)	22	—	0.3	5.0	—
Eggs (one)	50	6	—	0.1	1.5	—
Cheese (c)	30	8	0.3	0.2	0.4	—
Green and Leafy Vegetables...	100(d)	1	0.1	—	1.2	—
Potatoes	250	6	—	0.2	2.0	—
Legumes, Dried	10(e)	2	—	—	0.2	—
Cod-Liver Oil	3.5	—	—	—	—	Richest source
An available source of Vitamin C (from raw fruits and vegetables)	—	—	—	—	—	—
Total yield	—	77	1.6	1.7	10.2	Adequate

B.—Supplementary energy-yielding foods by means of which the individual's energy

Cereals as needed :						
Highly milled	250(f)	28	—	0.2	2.5	
or Whole grain... ..	250(g)	—	0.1	0.9	9.0	

Fats as needed.
Sugar as needed.

* The estimates are based on data in SHERMAN'S "Chemistry of Food and Nutrition", protein and 3.5 per cent. fat. The figures for vitamins, however, are converted to

I.*

PREGNANT AND NURSING WOMAN.

Vitamin A.	Vitamin B. ₁	Vitamin B. ₂	Vitamin C.	Vitamin D.	Calories.	Remarks.
International Units.		International Units.				
Rich (1,000-3,000)	Good (50-75)	Rich	Poor	Poor	660	(a) Calculations for lean meat.
Poor	Poor(b)	Rich	Poor	None	240	(a*) One-half calculated as available iron.
Rich (1,000-1,300)	Good (about 15)	Rich	None	25-40	70	(b) Except glands (liver and kidneys) and pork muscle.
Rich (800-1,000)	Poor	Good	Poor	Poor	125	(c) Calculated as cheddar cheese.
Rich (1,000-1,500)	Good	Good	Poor	None	30	(d) Estimated on basis of $\frac{1}{2}$ cabbage, $\frac{1}{2}$ lettuce, $\frac{1}{2}$ spinach.
Poor	Good	Good	Good	None	250	
Poor	Good	Good	None	None	35	(e) Calculated as beans.
Rich (1,800-3,500)	None	None	None	Rich (about 300)	30	
—	—		To yield 250-500	—	—	
Over 5,000	Over 150	Ade-quate	Over 500	About 300	1,440	

requirements can be met.

	Rich (about 250)				1,000	(f) Calculated as white flour.
					1,000	(g) Calculated as whole wheat.

4th edition, 1933. The figures for milk are calculated for a content of 3.2 per cent. international units and must be regarded as rough approximation only.

TABLE V.

Children, age 5-7 years (1,400 calories).

Food.	Amount. (grammes).	Calories.	Protein. (grammes).
<i>A. Protective Foods.</i>			
Milk	1,000	660	32
Egg	48	70	6
Meat, Fish, Liver or Cheese	30	40	6
Green leafy Vegetables	100	30	3
Potato (and other root vegetables)	150	150	3
Cod-Liver Oil	3	30	—
A source of vitamin C (raw vegetable or fruit).			
		980	50
<i>B. Supplementary Energy-yielding Foods.</i>			
Fats (butter, if possible)	20	150	—
Cereals (calculated as bread)	100	300	14
		450	14
Total		1,430	64

TABLE VI.

Children, age 12-14 years (2,600 calories (girls), 3,200 calories (boys)).

Food.	Amount. (grammes).	Calories.	Protein. (grammes).
<i>A. Protective Foods.</i>			
Milk	1,000	660	32
1 Egg	48	70	6
Meat or Fish or Liver or Cheese	90	120	18
Green leafy Vegetables	250	75	7
Potato (and other root vegetables)	300	300	6
Cod-Liver Oil	3	30	—
A source of Vitamin C (raw vegetable or fruit).			
		1,255	69
<i>B. Supplementary Energy-yielding Foods.</i>			
Fats (butter, if possible), cereals and other foods to furnish total calories as required.			

APPENDIX IV.

Conversion Factors for Meat, etc.

Wastage in distribution was considered in 1916 by a Committee of the Royal Society on Food Supplies during the War and deductions were made varying with each food so as to express it in terms of pure nutrients (protein fat and carbohydrate, etc.) and to estimate the number of calories provided. Figures for protein and carbohydrate, which appear in the Royal Society's Report on Food Supplies (1917) were based on the work of Atwater and Plimmer, who, so far as meat is concerned, merely made laboratory estimations of actual joints and assumed that these were representative of all carcasses.

Research has been undertaken with a view to revising the existing conversion factors for meat, the first objective being to ascertain the food values of the total bacon consumed in this country. With the co-operation of the Bacon Development Board and the Danish Bacon Company representative samples of bacon and ham were obtained and after mincing were sent to Dr. R. A. McCance of King's College Hospital for analysis. The cutting, anatomical measurements, mincing, weighing and packing were carried out at the factory of Messrs. T. Wall and Sons, Ltd., Acton, under the supervision of Dr. J. Hammond, of Cambridge University, and Mr. A. N. Duckham, of the Bacon Development Board. Samples of boneless beef were also obtained and sent to Dr. McCance for analysis. The results for bacon and ham will shortly be published. Preliminary results indicate that there are a higher proportion of protein and a lower proportion of fat in the bacon and ham supply than are indicated in earlier analyses. This is shown in the following table:—

Comparative Analyses of Bacon and Ham.

		Per 100 grams.		
		Protein.	Fat.	Energy Value (Calories)
1. <i>Dr. McCance (1936).</i>				
	Tank Cured Wiltshire Side (Danish) ...	14.3	37.1	404
	Dry Cured Wiltshire Side (British) ...	12.3	49.3	509
	Midland Cut (British Shoulder Belly) ...	10.5	61.1	611
	York Ham (British)	15.	49.	517
2. <i>Plimmer (1918).</i>				
	Bacon Side (type unspecified)	9.7	55.7	558
	Ham " "	13.1	46.0	482
3. <i>Atwater and Bryant (1906).</i>				
	Bacon " Edible Portion "	10.5	64.8	646
	Ham Smoked " Edible Portion "	16.5	38.8	429

These values exclude the weight of bone but include that of rind, the nutritive value of the rind being also included. (Whether rind was included in Atwater and Bryant's "Edible Portion" value is uncertain.)

The following Table shows the results of Dr. McCance's analyses of frozen meat:—

Estimated Composition of Frozen Meat.

	Veal.		Beef.				Mean.
	Source.		Source.				
	New Zealand.	Uruguay.	Australia.	Argentine.	New Zealand.	South Africa.	
Total nitrogen	gm./100 gm. 3.1	gm./100 gm. 3.2	gm./100 gm. 3.40	gm./100 gm. 3.08	gm./100 gm. 3.8	gm./100 gm. 3.35	gm./100 gm. 3.41
Purine nitrogen	0.057	0.045	0.052	0.053	0.056	0.048	0.052
Fat	2.66	4.6	6.65	12.0	1.8	8.5	7.24
Water	75.2	75.4	67.6	66.3	73.6	70.3	69.45
Sodium	mg./100 gm. 95	mg./100 gm. 94	mg./100 gm. 82	mg./100 gm. 77	mg./100 gm. 61	mg./100 gm. 73	mg./100 gm. 73
Potassium	380	375	365	338	445	338	396
Calcium	10.3	10.2	9.9	8.9	7.2	8.8	8.7
Magnesium	25	26.3	25.7	23	26	24.5	24.5
Iron	1.58	2.01	3.46	4.1	4.4	3.0	3.74
Copper	0.22	0.12	0.16	0.18	0.15	0.145	0.159
Phosphorus	210	190	197	205	200	188	198
Chlorine	94.5	101	89	70	57	77	73

HEALTH BULLETIN



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INTRODUCTION.

The purpose of this Bulletin is to summarise the available knowledge about the nutritive value of Indian foodstuffs for the benefit of public health workers, medical practitioners, superintendents of residential institutions and others interested in practical dietetics. With the help of the tables provided it is possible to work out "balanced diets" for individuals or groups. To do this, however, it is necessary to know what is meant by a "balanced diet". A brief statement outlining modern dietetic principles is therefore provided in the first sections of the Bulletin.

The bulk of the data presented is based on work carried out in the Nutrition Research Laboratories, Coonoor, where a special enquiry into the nutritive value of Indian foods has been financed by the Indian Research Fund Association. The Director and staff of the Laboratories are responsible for the preparation of the Bulletin. Use has, however, also been made of scientific articles published in India and elsewhere (notably from the Department of Bio-chemistry and Nutrition, All-India Institute of Public Health, Calcutta under Professor H. Ellis C. Wilson) which contain material of value. While a good deal of more work is necessary on the nutritive value of Indian foodstuffs, sufficient data are already available to justify the publication of the Bulletin for use in practical nutrition work.

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HEALTH BULLETIN.

The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets.

DIETARY REQUIREMENTS.

Foodstuffs supply fuel for the body and they contain proteins, fats, carbohydrates, vitamins and various mineral salts. Proteins, fats and carbohydrates are sometimes known as the energy-yielding food factors, since they are "burnt" or oxidized in the body to provide the energy necessary for life. Vitamins and mineral salts do not supply energy in appreciable quantities, but they play an important part in the physiological functions of the body. Water is also a necessary dietary element. Human beings, like other animals, require a sufficiency of these if they are to live and thrive, and in a well balanced diet they are present in correct proportions. Our present knowledge of what constitutes an adequate or optimum diet is based on an enormous amount of research work on human beings and laboratory animals carried out in many countries. We have a very fair idea of how much of each food factor is required and we can state requirements in terms of common foodstuffs.

CALORIES.

In drawing up a new diet schedule, or in assessing the value of an existing schedule, it is essential to know whether enough food is being provided. It might be thought that it is easy to discover whether, let us say, a group of labourers or the boys in a boarding school are getting enough to eat; if their food is insufficient, they will be hungry and complain about it. But experience has shown that human beings can adapt themselves, at a low level of vitality and with their powers impaired, to an insufficient ration, and scarcely realise that they are under-fed. The nutrition worker, in setting up standards of food requirements, ignores the remarkable faculty of the body to adapt itself to semi-starvation. His standard of food intake implies full satisfaction, enough to enable human beings to lead an energetic life at a reasonably high level of working capacity.

Quantitative food requirements are usually estimated in terms of heat units—calories. Let us first illustrate the problem to be discussed by a simple example. A group of coolies is provided with a ration of 17 ozs. of rice and 2 ozs. of pulse (dhal) per head per day, and very little food from other sources can be obtained by them. There are complaints that the coolies are lazy, that they work languidly and reluctantly. By reference to the Tables (p. 18) and a simple calculation, we discover that this amount of food would provide about 2,100 calories per day. The question arises: are they getting enough food? Or, in other words, are 2,100 calories a day sufficient for an adult man performing manual work?

An expert commission of the League of Nations* has drawn up the following statement about energy requirements:—

(a) *An adult, male or female, living an ordinary everyday life in a temperate climate and not engaged in manual work is taken as*

*The Problem of Nutrition, Volume II. Report on the Physiological Bases of Nutrition 1936.

the basis on which the needs of other age-groups are reckoned. An allowance of 2,400 calories net per day is considered adequate to meet the requirements of such an individual.*

(b) *The following supplements for muscular activity should be added to the basic requirements in (a) :—*

Light work : up to 75 calories per hour of work.

Moderate work : up to 75—150 calories per hour of work.

Hard work : up to 150—300 calories per hour of work.

Very hard work : up to 300 calories and upwards per hour of work.

India is mainly an agricultural country and the "average Indian man" is engaged in a manual occupation. There are justifiable reasons for reducing "basic" calorie requirements in a warm country, in which the diet consumed is largely vegetarian, below the League of Nations standards. Let us suppose that an Indian male, of sedentary occupation, requires some 2,150 calories, a figure 10 per cent. below that of the League Commission. Six hours "moderate" work at the lowest reckoning, will involve an increase of requirements to roughly 2,600. We shall not be very far out if we reckon the minimum calorie needs of an average Indian, engaged in ordinary easy-going agricultural or coolie work as 2,500—2,600 calories per diem. Those who perform heavy manual work will probably require about 2,800—3,000 calories per day, as is indicated by the League Commission's figures; if the agriculturist is to work very strenuously on his holding, he must have a correspondingly high calorie intake. A similar high intake is required by athletic young men such as university students. It scarcely needs to be said that a large man working in a cold climate will require more food than a smaller man working equally hard in a warm climate.

It is usual to assess the food requirements of women and children as fractions of those of the "average man", various co-efficients being applied to the different age and sex groups. The following scale of co-efficients and calorie requirements is put forward as sufficiently accurate for practical nutrition work in India :—

Scale of Average Calorie Requirements.

				Co-efficient.	Calories required.
Adult male (over 14)	..	..	..	1·0	2,600
Adult female (over 14)	..	..	..	0·8	2,080
Child 12 and 13 years	..	..	..	0·8	2,080
Child 10 and 11 years	..	..	..	0·7	1,820
Child 8 and 9 years	..	..	..	0·6	1,560
Child 6 and 7 years	..	..	..	0·5	1,300
Child 4 and 5 years	..	..	..	0·4	1,040
Child 2 and 3 years	..	..	..	0·3	780
Child 0 to 2 years	..	..	..	0·2	520

* The term "net calories" refers to the amount of energy available from the food actually assimilated.

It must be emphasised that this scale is a somewhat arbitrary one. Physique, habits of life and other factors are so variable in different areas that no one scale of energy requirements and co-efficients could be entirely suitable for application throughout the country. A somewhat higher scale of requirements would perhaps be more appropriate for North India. It is possible that the proposed scale puts the requirements of an adult woman at too high a figure. During pregnancy and lactation, however, the needs of a woman may equal or exceed those of a man. The League of Nations Commission assesses requirements during the e periods as follows :—

	Calories.
Pregnant woman	2,400
Nursing woman	3,000

These figures are definitely too high for Indian women, but they bring out the point that women need more food when they have to nourish a child in the womb or at the breast.

With the help of the Tables in the Bulletin, the calorie content of diets can be worked out and compared with requirements as suggested ; or, conversely, diet schedules yielding approximately the right number of calories can be constructed. In dealing with a group of mixed age and sex composition, the number of "consumption units" in the group—its "*adult man-value*"—is first calculated. Let us take a simple example. A family consisting of father, mother and 3 children aged 10, 8 and 6 respectively has a "man-value", on the above scale, of 3·6, and its daily calorie requirements would work out at $2,600 \times 3\cdot6$. If it is necessary to draw up a diet schedule for the family, food supplying roughly this number of calories should be included in the schedule. Suppose analysis of the existing diet of the family indicates that total intake per day is only 7,000 calories, *i.e.*, about 1,950 calories per "consumption unit". Comparison of this value with the scale shows that the family is not getting enough to eat. The same method of approach is applicable in the case of larger groups in boarding schools, asylums, etc.

Commonsense must always be used in drawing up new diet schedules, or in assessing the adequacy of existing ones. It is usually better to err on the side of excess by 100—150 calories to allow for waste of all kinds, including the inevitable "leakage" of food which occurs in large institutions. Standards of calorie requirements are applicable only to reasonably large numbers, and not to individuals. The relation between calorie requirements and such factors as work, activity and climate must be borne in mind.

It might be thought that there is little danger that children or adults housed in charitable institutions under careful and well-meaning management should be under-fed. But experience has shown that this is not infrequently the case in India. Superintendents of children's institutions should take particular care that *enough* food is provided. The children

themselves, often coming from homes in which they were half-starved, are not likely to complain of hunger in circumstances of *relative* abundance.

PROTEIN.

The next step, in constructing a balanced diet, is to ensure that it is satisfactory in quality. Protein is perhaps the most important of the food factors ; it supplies building material for the body and makes good the loss of tissue which occurs as the inevitable result of living at all. It can also be used by the organism as a source of energy.

As is apparent from the Tables, nearly all common foodstuffs contain protein, but the amount they contain varies widely. Animal foods such as milk, eggs, fish, and meat are rich in protein. The common cereals, such as rice, wheat, millet, barley, etc., contain a fair proportion of protein, rice being the poorest of all cereals in this respect. The outer layers of the grain are richer in protein than the inner starchy kernel, and when wheat and rice are highly milled there is some loss of protein as well as of other valuable food factors, such as vitamins and mineral salts. Among the vegetable foods, the pulses are richest in protein. Leafy and root vegetables, and fruits do not contain much protein, but if they are abundantly present in a diet their contribution to total protein intake is by no means negligible.

It is important to remember that growing children require, per unit of body weight, more protein than adults. The new tissue which is being laid down is largely built of elements drawn from protein. For the same reasons the protein needs of women during pregnancy and lactation are greater than at other times. The following scale of protein requirements is suggested as a rough guide for practical nutrition work :--

Protein requirements.

Age and sex.			Co-efficient.	Grammes per day.
Man	18 to 60	.. ..	1.00	65
Woman	18 to 60	.. ..	0.85	55
Boy	10 to 17	.. ..	1.20	80
Girl	10 to 17	.. ..	1.10	70
Child	6 to 9	.. ..	0.90	60
Child	2 to 6	.. ..	0.60 to 0.80	40—50

This scale falls short of the ideal as defined by modern physiologists, and may often with advantage be exceeded. It is nevertheless excessive, as far as India is concerned, in the sense that economic circumstances and dietary habits often prevent its attainment.

The total protein content of a diet can be estimated by means of the Tables. But more important than the total protein content of a diet is the proportion of protein of high biological value it includes. Proteins contained in various foods differ in their *amino-acid* constitution ; amino-

acids are the bricks with which tissue is built and replaced, and the more closely the amino-acid make-up of a protein resembles that of the tissues the greater its value. Another factor to be considered in assessing the value of the proteins of a foodstuff is their digestibility.

In general, protein derived from vegetable foods is of less value to the body than protein derived from animal foods. It is, indeed, probable that no combination of vegetable proteins can support growth and lay the foundations of healthy vigorous manhood and womanhood as effectively as a mixture of vegetable and animal proteins. The Commission of the League of Nations referred to reported as follows :—

“ During growth, pregnancy and lactation, some animal protein is essential, and in the growing period it should form a large proportion of the total protein.”

We may recommend that this proportion should be *at least one fifth*. The best source of animal protein for growing children is milk, derived from the cow or other species. It must be emphasised that skim milk is as rich in good protein as whole milk, and butter-milk of good quality is also a useful source. Eggs, fish, liver and muscle meat also contain proteins of high biological value.

Diets for growing children which do not contain a fair proportion of animal protein cannot be regarded as satisfactory. In devising “ cheap balanced diets ” in India the inclusion of animal protein in adequate amounts is the point which presents the greatest difficulty.

Data about the biological value of a number of proteins are given in Appendix I.

FAT.

Fat must be included in ordinary diets, but we have no exact knowledge of the quantity required. It is probably advisable that not less than 45—60 grammes ($1\frac{1}{2}$ —2 ozs.) should be consumed daily. Most diets in India are low in fat. Fat is of value to the body in a number of ways, and a diet low in animal fat is often deficient in certain important vitamins. Animal fats, such as butter or ghee, contain vitamin A, while most vegetable fats and oils lack this factor. Ghee adulterated with vegetable oil may contain little or no vitamin A. There is one vegetable oil which is very rich in vitamin A activity, namely, red palm oil, which is obtained from the fruit of the palm *Elaeis guineensis*, grown in West Africa, Malaya and Burma. Apart from oils and fats which are consumed as such, the following foodstuffs are among those rich in fat : coconuts, nuts, soya bean, avocado pear.

CARBOHYDRATES.

Carbohydrates are the body's chief source of energy. Grain foods and root vegetables are largely composed of carbohydrates, and sugar is wholly carbohydrate. The carbohydrates are necessary constituents of the diet, but when, as commonly in India, they are present in excessive proportion, the diet becomes ill-balanced. In working out diet schedules,

requirements of protein, fat, vitamins and minerals should first be attended to ; subsequently carbohydrate-rich foods can be included in sufficient quantities to fulfil energy requirements.

MINERAL SALTS.

The calcium, phosphorous and iron content of most common Indian foods is given in the Tables. It is probable that these are the elements which are most likely to be insufficiently supplied by average human diets. There are a number of other elements needed by the body ; it may be assumed that if the diet is well-balanced generally enough of these elements will be obtained. The special problem of iodine deficiency in goitrous areas will not be considered here.

CALCIUM.

Calcium is found abundantly in milk (including skim milk and butter-milk), cheese and green leafy vegetables. Murraya, amaranth, fenugreek and drumstick leaves are rich in calcium. Children need relatively more calcium and other minerals than adults, just as they need relatively more protein.

Expectant and nursing mothers require a large intake of calcium. A healthy breast-fed baby of 3 months contains a great deal of calcium in its bones, all of which has been drawn from its mother's blood and its mother's milk. If the mother's diet is deficient in calcium, then the calcium present in her own bones is drawn upon, and her health and probably that of the child, will suffer. Since there is this enormous drain of calcium during pregnancy and lactation, a large intake of milk during this period is recommended.

The usual text-book figures representing calcium requirements are 0.68 gramme daily for adults, and 1.0 gramme for children. These figures allow a high " margin of safety ". Indian diets, particularly diets based on milled rice, may supply less than 0.20 gramme of calcium daily. This intake is too small. The diet of growing children should contain upwards of 0.60 gramme of calcium daily and that of pregnant and nursing women rather more.

The best source of calcium is milk. Green vegetables and certain of the millets—*e.g.*, ragi—are particularly rich in calcium, but the calcium contained in such foods may not be as well absorbed and assimilated as milk calcium.

The habit of chewing betel leaves coated with lime (calcium oxide), which is common throughout India, increases intake of calcium. At present we have no precise knowledge of the value to the body of calcium consumed in this manner.

PHOSPHORUS.

It is usually stated that rather more than 1.0 gramme of phosphorus daily should be supplied by the diet. Cereals in the raw state are fairly rich in phosphorus, but considerable loss of this element occurs on cooking. If a diet contains sufficient calcium, it may be taken for granted that its phosphorus content is satisfactory.

IRON.

Hæmoglobin, the red pigment of blood—a most important physiological substance which transports oxygen from the lungs to the tissues—contains iron as an essential constituent of its molecule. Iron is needed by the body for blood formation. When destruction and loss of blood corpuscles is taking place as in such conditions as chronic malaria and ankylostomiasis (hook-worm) iron requirements are increased.

It is suggested that a well-balanced diet for a growing child or an adult should contain 20 mgs. of iron according to the Tables. This figure gives a “margin of safety” and allows for the possibility that the iron content of foods in certain parts of India may be lower than that of the foods analysed in the coonoor laboratories. The iron in certain foods is less “available”—*i.e.*, less well assimilated—than the iron in others. A high percentage of the iron in pulses and meat, for example, is “available” but only a low percentage of the iron in vegetables. If, however, total iron intake from all foods present in the diet exceeds 20 mgs. per day, it is possible that sufficient iron will be assimilated. The percentage of available iron in a number of foodstuffs is given in Appendix II.

In the *treatment* of certain forms of anæmia, iron medication is more effective than the consumption of a diet containing abundant iron rich foods. For the *prevention* of anæmia, however, an iron rich diet is valuable. Pregnant women are particularly prone to suffer from anæmia.

VITAMINS.

Vitamin A.

Vitamin A is found in animal fats; in whole milk, curds, butter, unadulterated ghee, egg yolk, liver, fish, etc. Its richest natural source is fish liver oil: *e.g.*, halibut liver oil and cod liver oil. But it is not only animal foods which possess vitamin A activity. While vegetable foods do not contain vitamin A, the pigment carotene, which is present in many such foods, appears able to fulfil the physiological functions of vitamin A in the body. Vitamin A requirements can thus be covered by the consumption of a suitable vegetable diet. Leafy vegetables, such as spinach, lettuce, cabbage, amaranth leaves, coriander leaves, drumstick leaves, celery leaves, and ripe fruits such as mangoes, pappaya, tomatoes, oranges, etc., are rich in carotene. Carrots are also a good source.

In the Tables the vitamin A and carotene content of foodstuffs is expressed in terms of international units. Our knowledge of vitamin A requirements is at present limited. It may be suggested, however, that a well-balanced diet should contain a daily minimum of 3,000 international units. In Western countries a large proportion of the total vitamin A activity of the diet is usually derived from vitamin A contained in animal foods. Animal foods rich in vitamin A are, however, expensive foods, and in the East it will usually be found that the easiest and cheapest way of ensuring a sufficiency of vitamin A units is to increase intake of green leafy vegetables. For example 3 ozs. (about 85 grammes) of amaranth leaves will supply more than 3,000 international units and cover adult

requirements. The needs of children of school age, which may possibly exceed those of adults, can be covered in the same way by a high intake of green leafy vegetables. In the case of infants and young children, and sickly and mal-nourished children of all ages, vitamin A may be supplied in the form of a daily dose of fish liver oil. The addition of cod liver oil increases the nutritive value of the diet of the average Indian child.

The vitamin A activity of any given foodstuff is variable, depending on a number of factors. That of milk and butter for example, fluctates according to the diet of the animal from which it is derived; it has been observed in Europe that "summer" milk, obtained from cows fed on succulent green grass rich in carotene, contains more vitamin A than "winter" milk from stall-fed cows. Prolonged heating of ghee in an open pan may cause destruction of vitamin A. In the case of leafy vegetables, a good rough indication of carotene content is their greenness. The greener the better, and the fresher the better. Ordinary cooking does not destroy the carotene present in vegetables.

For a number of foods the Tables give a range of vitamin A and carotene content. In devising diets, a figure lying midway between the two extremes may be used. In the absence of information about the vitamin A activity of a vegetable food, it may be assumed that all green leafy vegetables are richly endowed in this respect, while other vegetables, cereals, legumes, etc., are less important sources of carotene.

Vitamin A deficiency is common in India, and care must be taken to ensure that diets supply a sufficiency of this vitamin. Reference to the effects of vitamin A deficiency will be made in a later section.

The B Vitamins.

A whole group of vitamins is included under this head.

Vitamin B₁, commonly known as the "anti-beriberi" vitamin, is found in unmilled cereals, pulses, eggs, fruits, nuts, most vegetables, glandular organs such as liver and to some extent in muscle meat and milk. A diet largely composed of milled rice contains insufficient vitamin B₁, and may give rise to beriberi, which is common in certain parts of India. Parboiled rice, even when milled, contains vitamin B₁.

The Vitamin B₁ requirements of school children and adults may be estimated at 300 international units per day. It is not difficult to ensure that a diet contains this quantity of the vitamin. If 4 ozs. of unmilled cereal, 6 ozs. of leafy and other vegetables and 2—3 ozs. of pulses are consumed daily, it is probable that enough vitamin B₁ will be obtained, even if the rest of the diet is composed of milled rice. The smaller the supply of vegetables, pulses, and fruits, the more important it becomes to avoid a preponderance of milled cereal in the diet. Even when nine-tenths of the diet is based on rice, beriberi will not usually follow if the rice is consumed in the "home-pounded" form. But if rice is subjected to several washings before consumption a great proportion of whatever vitamin B₁ it contains may be removed, and there will be a loss of mineral matter. Rice which is mouldy and full of weevils is likely to

be subjected to most washing. Such rice is consumed by the very poor whose diet contains only small quantities of foods other than rice, and who are in the greatest need of the elements lost in washing.

It is noteworthy that milk, which is a good source of most of the important food factors, is not rich in vitamin B₁.

Vitamin B₂ (a term covering several vitamins) is an important food factor. The Tables give a rough idea of how it occurs in foodstuffs. All cereal foods are poor sources of it, milled rice being the poorest. Certain of the common pulses contain it fairly abundantly; among these are Bengal gram, black gram, and red gram. Green leafy vegetables and certain roots and tubers, are fairly rich, but fruits in general probably do not contain much of this vitamin. Its richest sources are yeast, milk products (including skim milk, butter-milk, curds and cheese), lean meat, liver, eggs, pulses and green vegetables.

"Soreness" of the angles of the mouth and the tongue is probably caused by deficiency of vitamin B₂. It occurs most commonly in those whose diet consists largely of milled rice. Rapid cure follows the daily consumption of $\frac{1}{2}$ —1 oz. of dried yeast, $\frac{1}{2}$ to 1 pint of good milk, or 2—3 eggs.

Vitamin C.

Vitamin C or ascorbic acid, the vitamin which prevents scurvy, is found in fresh fruits and vegetables. Among vegetables, the green leafy varieties are the best sources of this vitamin. When vegetables become dry and stale, most of the vitamin C originally present is destroyed.

Pulses and cereal grains in the ordinary state contain no vitamin C. When, however, they are allowed to sprout, the vitamin is formed in the grain and in the growing green sprouts. A method of causing grains to sprout is described in Sir Robert McCarrison's "Food" as follows:—

"Dhal, gram, wheat, unsplit peas or any other grain is first soaked in water for 24 hours and is then spread out on damp earth or on a damp blanket and covered over with a moist cloth or sack (gunny bag) which is kept moist by sprinkling water upon it from time to time. After two or three days the grains will have sprouted and be ready for use".

"The sprouted grains should be eaten raw or after cooking for not more than 10 minutes".

When fresh vegetables and fruits are not easily obtained, sprouted grains may be used as a cheap and easily available source of vitamin C. Sprouted pulses may contain 10—15 milligrammes of vitamin C per 100 grammes.

A well-balanced diet for school children and adults should contain some 30—50 mgs. of vitamin C per day. Vitamin C is sensitive to heat, and loss occurs in cooking, particularly if cooking is prolonged. Nevertheless, the inclusion of a few ounces of fresh fruit and leafy and

other vegetables in a diet will ensure that its vitamin C content is satisfactory. In the case of infants fed on boiled fresh milk or re-constituted dried milk, special attention to vitamin C requirements is necessary. These can be met by giving fruit juice in small quantities.

Vitamin D.

Vitamin D, the vitamin which prevents rickets and osteomalacia, is found in liver and liver oils, egg yolk, and in milk and milk fat (*e.g.*, ghee) obtained from animals feeding on green pastures and exposed to sunlight. Fish liver oil is its richest natural source. Vitamin D is formed in the skin by the action of sunlight, and hence rickets is particularly apt to occur in infants kept in dark houses, while osteomalacia in India is often found in the North among women who keep purdah. Probably minor degrees of rickets are more common in infants and young children throughout India than is generally supposed. Often the cheapest and easiest way of supplying vitamin D is by exposure of the body to sunlight. Cod liver oil and medicinal preparations of vitamin D cost money. The sun is free. There is a close connection between vitamin D and calcium and phosphorus requirements. When little vitamin D is obtained, and at the same time insufficient calcium is present in the diet, the danger of rickets and osteomalacia is increased. This is an additional reason why attention must be given to calcium intake.

An abundant intake of vitamin D helps to ensure the development of strong regular teeth. A good supply of this vitamin during pregnancy benefits the mother and helps to ensure the satisfactory future development of the child.

THE EFFECT OF COOKING ON NUTRITIVE VALUE.

The effect of heating and cooking on the nutritive value of food-stuffs is, on the whole, less pronounced than is generally imagined. Vitamin C is destroyed by moderate degrees of heat, and for this reason the inclusion of some raw fruit in the diet is desirable. When foods are cooked for prolonged periods in excessive quantities of water, some of the vitamins and salts they contain may pass into the water, and will be lost if the water is discarded. A considerable loss of phosphorus occurs during the washing and cooking of rice. The addition of washing soda (a strong alkali) to cooking water, for the preservation of colour or to facilitate cooking, tends to promote vitamin destruction. Conversely, a highly acid substance like tamarind has, when added to cooking water, a preservative effect. It must be added that we need more information about the effect of ordinary Indian methods of preparing and cooking foods on nutritive value.

MALNUTRITION.

It is advisable that those who are responsible for the institutional care of children, etc., and all who are concerned with practical nutrition work, should have some idea of the effects on the body of a diet which is ill-balanced and defective—*e.g.*, of a diet which is largely composed of milled cereals and contains an insufficiency of proteins, mineral salts

and vitamins—and which calls for improvement. There is a long list of diseases, common in India, due in some way or other to dietetic causes. Such are: beriberi, certain anaemias of pregnancy, keratomalacia, osteomalacia. States of malnutrition which fall short of serious disease are wide-spread. A well-balanced diet is essential if growth and development are to take place normally. A badly fed child is often small for its age and thin; its "weight for height" will be below average. It will fall sick easily. The frequency of minor ailments in school children can be reduced by improving the diet. A certain apathy, a lack of "pep", of enthusiasm for work and play, is characteristic of the malnourished. The state of the skin is a sensitive index of faulty feeding; a rough dry skin, or a skin covered with a papular eruption, suggests faulty feeding and in particular vitamin A deficiency. Everybody knows that a well-fed animal exhibits a certain glossiness and sleekness of fur—a "good coat"—which is not seen in poorly fed animals. Similarly a well-fed human being has a glossy skin and a glow of health. Bright clear eyes are also a sign of satisfactory feeding. Xerophthalmia (areas of dryness on the conjunctivae of the eyes sometimes covered with white exudative patches known as Bitot's spots) is associated with vitamin A deficiency. Sore-mouth and tongue and erosions at the angles of the mouth are found in ill-fed children; in the properly fed child the tongue should be smooth and evenly coloured and not show enlarged papillae, fissures and areas denuded of the superficial epithelium. Such lesions, occurring most commonly in milled rice eaters, may be due to vitamin B₂ deficiency; they can often be rapidly cured by increasing milk intake. Spongy bleeding gums suggest vitamin C deficiency—mild scurvy—and call for a greater consumption of fresh fruit and vegetables.

SUMMARY OF DIETETIC PRINCIPLES.

Human beings, and particularly children, cannot thrive at their best on a diet composed largely of cereals such as rice, millet, etc., and insufficiently supplemented by other foods. To make good the deficiencies of such a diet, they must consume fair quantities of foods like milk, green vegetables, eggs, fruits, etc. These are sometimes known as the "protective" foods, since they are rich in proteins, vitamins, and mineral salts and protect the body against the ills which result when the diet is largely based on less nutritious foods, such as milled rice. Cod liver oil, which is very rich in vitamins A and D, may for present purposes be classed as a most valuable "protective" food.

In general, diets in India are defective because they do not contain "protective" foods in sufficient abundance. *Our aim in public health nutrition work in general, and planning, "well-balanced" diets, must be to increase intake of "protective" foods.* The classes in the community which are particularly likely to suffer if their diet is defective are infants and growing children, and expectant and nursing mothers.

THE INVESTIGATION AND PLANNING OF DIETS.

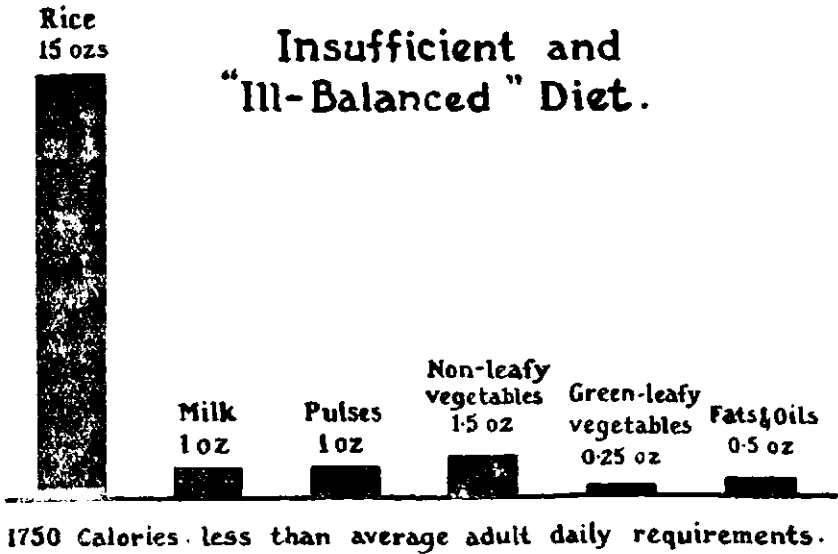
A concrete example will illustrate the methods to be followed in improving diets and drawing up satisfactory diet schedules. Let us

suppose that the daily diet schedule of an institution, or of any group of people, works out as follows in amounts per consumption unit per day:—

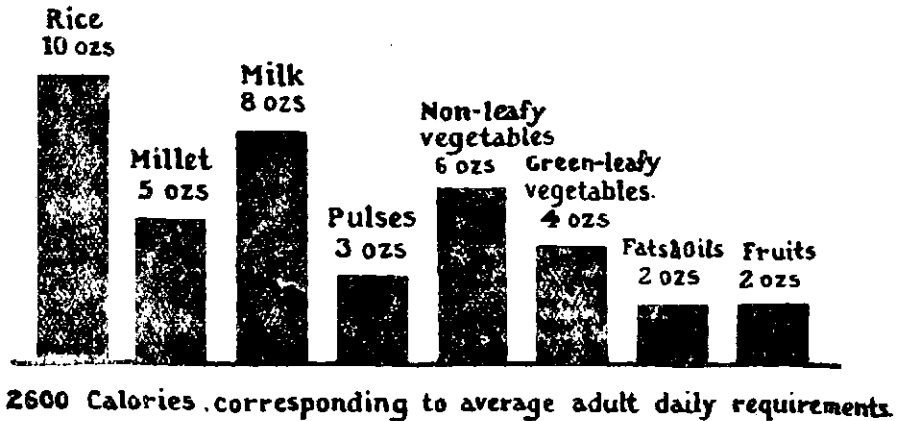
					Ozs.
Milled rice	..	..	..	..	15·0
Milk	..	..	..	..	1·0
Pulses (dhal arhar)	..	..	..	..	1·0
Brinjal	..	..	..	..	1·0
Ladies fingers	..	..	..	..	0·5
Amaranth	..	..	..	..	0·25
Gingelly oil	..	..	..	..	0·50

This diet is shown diagrammatically in the Figure (the “ill-balanced” diet).

Insufficient and "Ill-Balanced" Diet.



"Well-Balanced" Diet.



An insufficient and ill-balanced diet compared with an adequate and well-balanced diet.

By reference to the Tables, the nutritive value of the ill-balanced diet can be worked out. Its content of calories, etc., is roughly as follows :—

Protein	..	..	..	..	..	38 gms.
Fat	..	..	..	..	..	19 gms.
Carbohydrate	..	..	..	..	..	357 gms.
Calories	..	..	..	..	..	1750
Calcium	..	..	..	..	..	0·16 gms.
Phosphorus	..	..	..	..	..	0·60 gms.
Iron	..	..	..	..	..	9·00 mgs.
Vitamin A	(international units)	..	..	..	..	500
Vitamin B ₁	..	..	..	..	..	160
Vitamin C	..	..	..	..	..	15·0 mgs.

It is at once apparent that this diet is insufficient in quantity and that it fails to supply the necessary requirements of any of the food factors enumerated. Such a diet, it may be remarked, is typical of diets consumed by millions in India.

The following adjustments might be made in a defective diet of this nature in order to make it adequate and "well-balanced". The "well-balanced" diet is illustrated in the Figure.

					Ozs.	
Raw milled rice	..	..	..	..	10
Cambu	..	..	..	..	5
Milk	..	..	..	..	8
Pulses (dhal arhar 1 oz)	}	..	..	..	3
(black gram 2 ozs)						
Non-leafy vegetables.	{	brinjal	2 ozs.	}
		ladies fingers	..	..	1 oz.
		snake gourd	..	..	1 oz.
		cluster beans	..	..	1 oz.
		drumstick	..	..	1 oz.
Leafy vegetables	{	amaranth leaves	2 ozs.	}
		drumstick leaves	..	..	1 oz.
		spinach	..	..	1 oz.
Gingelly oil	..	..	..	..	2
Fruit	{	mangoes	1 oz.	}
		ripe plantains	..	..	1 oz.

Five ozs. of millet (cambu) replace a similar quantity of milled rice ; this increases intake of all the essential food factors, but notably that of protein and vitamin B₁. The additional milk supplies proteins of high biological value, calcium, and some vitamin A. The extra pulses increase total protein consumption and add calories. Intake of vegetables is greatly increased, with consequent all round improvement ; the green leafy vegetables will be rich in vitamin A (carotene), a factor somewhat lacking in the remainder of the diet, and also in vitamin C. Two ozs. of fats and oils will provide a considerable addition of calories. The inclusion of fruit ensures that vitamin C requirements are more than fulfilled. The changes will also raise intake of vitamin B₂.

The composition of the "well-balanced" diet is roughly as follows :—

Protein	73 gms.
Fat	74 gms.
Carbohydrate	408 gms.
Calories	2590
Calcium	1.02 gms.
Phosphorus	1.47 gms.
Iron	44.00 mgs.
Vitamin A (international units)	over 7000
Vitamin B ₁	over 400
Vitamin C	about 170.0 mgs.

This diet contains enough calories to supply the requirements of an average man. All the important food factors are present in sufficient quantities, with a fair "margin of safety". The chief cereal in both the "ill-balanced" and "well-balanced" diets is milled rice. If, however, the staple cereal is wheat or millet, the principle of balance between the cereal and the other elements in the diet applies equally.

IMPROVEMENT IN RELATION TO COST.

Well-balanced diets are in general more expensive than deficient ones. For example, the "ill-balanced" diet shown in the diagram, which is largely composed of rice and contains very little milk, vegetables, or fruit, would cost about Rs. 2-8-0 per adult per month; the "well-balanced" diet, richer in milk and other foods, about Rs. 5 to 6. It is at this point that the nutrition worker encounters the main difficulty. Those who suffer from under- and mal-nutrition usually cannot afford to purchase a satisfactory diet. Many residential institutions for children in India, for example, are very short of money, and have often to feed their boarders on Rs. 3 per head per month or a good deal less. Now it is difficult, in fact impossible, to supply a really satisfactory diet for such sums.

But even when poverty prevents the purchase of a diet which satisfies modern standards of nutrition, it is often possible to make effective improvements with little increase in cost. It is desirable that children should consume upwards of 8 ozs. of milk a day—8 ozs. being an amount below that recommended as "optimum" by nutrition workers elsewhere. If available funds do not admit the addition of this quantity of whole milk, butter-milk, or skim milk reconstituted from skim milk powder, which are considerably cheaper, may be supplied. Even a little milk is better than none. Careful experiments have shown that the giving of 8 ozs. of skim milk daily to children fed on an average "ill-balanced" Indian diet results in an acceleration of growth and a great improvement in health and well-being. Such an addition is not very costly.

Diets in children's homes, and among the general population, are often low in fat. Addition of extra vegetable oil (at the expense of a quantity of cereal supplying an equivalent number of calories), does not greatly increase expenditure. Pure ghee or butter is, of course, preferable to vegetable fat, but very much dearer.

Other points to which attention should be given include the following:—If the cereal consumed is milled rice, an improvement in the nutritive value of the diet (and in the health of those consuming it) can be brought about by wholly or partially substituting whole rice, whole wheat, or one of the millets, particularly ragi. If milled rice remains the basis of the diet, it should be realised that the milled rice eater needs more “protective” food:—milk, green vegetables, fruits, etc.—than the consumer of whole rice or ragi. When the diet is almost wholly composed of rice—when people are so poor that they cannot afford to buy other foods except in minute quantities—then the state in which the rice is eaten becomes of paramount importance. Parboiled rice, even when milled, is superior in nutritive value (particularly as regards the anti-beriberi vitamin) to raw rice milled to the same degree.

Pulses are rich in protein and in the B vitamins. 2—3 ozs. per day increase the nutritive value of a diet largely composed of cereals. The soya bean is rich in protein, fat, and in vitamins A and B. If soya bean is to be widely used in India, considerable attention will have to be given to methods of preparing it in a palatable form. It does not seem, however, to have any advantage as a food for human beings over other pulses in common use in India, and the pulses in general are less valuable dietary supplements than animal foods such as milk, fish and meat.

Intake of green leafy vegetables should be not less than 4 ozs. per head per day. The cheaper varieties—amaranth leaves, coriander leaves, drumstick leaves, etc.—are as nutritious as the more expensive ones, such as lettuce. In children’s homes the available supply of green vegetables could often be increased by creating a vegetable garden to be tended by the children themselves.

Fruits should always be included in children’s diet. Plantains, a cheap fruit often supplied in hostels, are not of high nutritive value. Tomatoes and oranges and other “juicy” fruits are rich in vitamins and make a useful addition to diets of the poorer type.

PRACTICAL NUTRITION WORK IN GENERAL.

There are, of course, many kinds of public health nutrition work besides the planning of adequate diets. The task of the nutrition worker is often to make special additions (*e.g.*, milk, cod liver oil, various vitamin-rich preparations) to an unsatisfactory diet rather than to plan the whole diet afresh. Infant feeding is a special subject demanding special knowledge and training. But in all branches of practical dietetics the fundamental principles involved are the same, and an understanding of them is essential for successful work in this field.

Finally, it may be pointed out that it is not only the poor, whose choice in the matter of food is extremely limited, who are ignorant and prejudiced about diet. Plenty of people in India and elsewhere, who could afford to consume an excellent diet, and feed their children on an

excellent diet, do not in fact do so. One can readily find, among children of the more prosperous classes, cases of serious malnutrition and food deficiency disease.

NOTE ON FOOD VALUE TABLES.

The foodstuffs analysed were mostly obtained in the local market, Coonoor. Foods which may be described as common Indian foods, consumed throughout the country, originated in the majority of cases in the neighbouring plains of the Coimbatore district; others of a kind less widely used in India (*e.g.*, European vegetables such as lettuce) were largely grown in the neighbourhood of Coonoor, 6,000 feet above sea level. Among the foods analysed were some from other parts of India, including North India. The edible portion of the foodstuff, in a fresh state as possible, was used for the analysis. The method of analysis is described in a paper in the Indian Journal of Medical Research.*

The figures given represent percentages—*i.e.*, gramme per 100 grammes. Iron is expressed as milligrammes per 100 grammes. The great variety of Indian measures makes it difficult to supply metric and avoirdupois equivalents for the weights used in various provinces. In using the Bulletin in practice, the following conversion table may be useful:—

1,000 grammes (1 kilo)	..	=	2.2 pounds (avoirdupois).
„ „ „ „	..	=	87.5 tolas.
100 grammes	..	=	3.5 ounces (avoirdupois).
„ „ „ „	..	=	8.75 tolas.
1 pound (avoirdupois)	..	=	453.6 grammes.
1 ounce („)	..	=	28.4 „
1 tola	..	=	11.4 „

The vitamin A and carotene figures are almost entirely based on spectrographic assays while vitamin C₂ was estimated chemically. In the case of vitamin B₁, use has been made of results appearing in various journals. The vitamin B₂ estimates are based on biological assay in the Coonoor Laboratories. No international unit has yet been established for vitamin B₂ or any of its components, and it has been found necessary to adopt the older method of reckoning values by means of signs. † † † indicates a very rich source; † † a good source; † means that the vitamin is present but not in large amounts; “poor” means that the vitamin is shown to be present by biological tests, but that the foodstuff so labelled should be regarded as an almost negligible source of the vitamin.

The absence of figures or estimates of vitamin content means that tests have not yet been carried out.

* Ranganathan, *et al.* Indian Journal of Medical Research. 24. 3. January 1937.

TABLE OF

Cereals.

Name of foodstuff.	Botanical name.	Mois- ture %.	Pro- tein %.	Fat (Ether Extrac- tives). %	Mineral matter %.	Fibre %.	Carbohy- drate %.	
Arrow-root flour (West Indian).	Maranta arundi- nacea.	16.51	0.17	0.06	0.12	..	83.14	
Bajra or cambu	Pennisetum ty- phoideum.	12.41	11.59	4.99	2.65	1.22	67.14	
Barley ..	Hordeum vulgare	12.48	11.47	1.28	1.51	3.92	69.34	
Cholam ..	Sorghum vulgare	11.88	10.42	1.93	1.76	..	73.99	
Italian millet ..	Setaria Italica ..	11.23	12.31	4.65	3.24	7.95	60.62	
"Kootu" ..	Fagopyrum es- culentum.	11.33	10.26	2.36	2.42	8.60	65.03	
Maize, tender ..	Zea mays ..	79.36	4.33	0.46	0.65	..	15.20	
"Makhana" ..	..	12.75	9.70	0.14	0.52	..	76.89
Oatmeal ..	Avena sativa ..	10.68	13.55	7.59	1.78	3.46	62.94	
Pani-varagu ..	Panicum milia- ceum.	11.85	12.49	1.06	3.39	2.16	69.05	
Ragi ..	Eleusine coracana.	13.05	7.10	1.29	2.24	..	76.32	
Rice, raw, home- pounded.	} Oryza sativa ..	12.19	8.49	0.35	0.70	..	78.27	
Rice, parboiled homepounded.		12.63	8.50	0.39	0.86	..	77.62	
Rice, raw, milled		12.96	6.85	0.55	0.50	..	79.14	
Rice, parboiled, milled.		13.29	6.44	0.64	0.77	..	78.86	
Rice, white, puttu.		12.97	7.51	0.37	0.40	..	78.75	
Rice, black, puttu.		12.26	7.69	1.27	1.25	0.65	76.88	
Rice, beaten		12.23	6.63	1.15	1.73	..	78.26	
Rice, puffed.		14.68	7.46	0.12	3.41	..	74.33	
Sago ..		Metroxylon sago..	12.20	0.24	0.17	0.30	..	87.09

* See Footnote at

FOOD VALUES.

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ * (In- terna- tional units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.009	0.017	1.00	333.8	..	..	..	..
0.049	0.352	8.84	359.9	220	110	Poor	..	
0.025	0.225	3.70	334.8	Trace	150	Poor	..	
0.027	0.282	6.18	352.8	136	..	Poor	..	
0.026	0.287	6.25	333.6	..	195	..	..
0.068	0.299	13.20	322.4	..	300	..	..
0.005	0.102	0.68	82.3	42	..	..	3.5	
0.016	0.091	1.38	347.6	Trace	..	..	..
0.045	0.384	3.81	374.3	Trace	325	..	..
0.014	0.333	5.72	335.7	..	..	..	..
0.334	0.272	5.38	345.3	70	..	Poor	..	
0.007	0.165	2.22	350.2	..	100	Poor	..	
0.010	0.277	2.75	348.0	..	100			
0.007	0.108	1.02	348.9	0	26			
0.007	0.149	2.22	347.0	0				
0.008	0.084	3.33	348.4	..			..
0.012	0.241	4.93	349.7	..	100	Poor or none.	..	
0.016	0.217	8.00	349.9	..			..
0.024	0.162	6.15	329.1	..			..
0.019	0.006	1.27	350.9	0	..	..	..

end of Cereals table.

Cereals--contd.

Name of foodstuff	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives). %	Mineral matter %.	Fibre %.	Carbohydrate %.
Samai ..	<i>Panicum miliare.</i>	11.46	7.70	4.71	4.83	7.60	63.70
Jauwa millet ..	<i>Panicum crusgalli</i> var. <i>frumantaceum.</i>	11.87	6.22	2.23	4.44	9.83	65.41
"Singhara", dry	<i>Trapa bispinosa</i> ..	13.76	13.43	0.83	3.07	..	68.91
Vermicelli ..	..	11.67	8.66	0.44	0.47	..	78.78
Varagu or Kodu millet.	<i>Paspalum scrobiculatum.</i>	12.77	8.31	1.37	2.92	8.97	65.66
Wheat, whole ..	<i>Triticum vulgare</i>	12.77	11.77	1.45	1.49	1.20	71.30
Refined wheat flour.	<i>Triticum vulgare</i>	13.30	11.00	0.90	0.40	0.30	74.10

* All whole grain foods are rich in vitamin B₁, while milled grains are largely vitamin B₁ after milling.

Calcium (Ca) %	Phos- pho us (P) %	Iron (Fe) ings. %	Calorific value per 100 gms.	Carotene (inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ (Intern- tional units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.015	0.264	7.08	328.0	Trace	..	Poor	..	
0.019	0.282	2.86	306.6	..	..	..	..
0.069	0.443	2.35	336.8	..	..	..	..
0.020	0.079	0.33	353.6	Trace	..	..	..
0.039	0.242	5.17	308.2	..	..	..	..
0.054	0.315	5.34	345.4	108	230	+	..	
0.020	0.092	1.00	348.5	..	..	..	..

deprived of this vitamin. An exception is parboiled milled rice, which retains

Pulses.

Name of foodstuff.	Botanical name.	Mois- ture %.	Pro- tein %.	Fat (Ether Extrac- tives) %.	Min- eral matter %.	Fibre %.	Carbohy- drate %.
Bengal gram ..	<i>Cicer arietinum</i> ..	9.83	17.08	5.26	2.68	3.92	61.23
Bengal gram, roasted.	Do. ..	11.17	22.54	5.17	2.19	..	58.93
"Bhetmas" ..	<i>Glycine hispida</i> ..	8.80	41.29	16.95	4.49	4.25	24.22
Black gram ..	<i>Phaseolus mungo</i>	10.87	23.95	1.38	3.39	..	60.41
Cow gram ..	<i>Vigna catiang</i> ..	12.00	24.56	0.69	3.23	3.75	55.77
Field bean, dry	<i>Dolichos lablab</i> ..	9.60	24.94	0.78	3.21	1.38	60.09
Green gram ..	<i>Phaseolus radiatus</i>	10.42	23.96	1.26	3.57	4.10	56.69
Horse gram ..	<i>Dolichos biflorus</i>	11.81	22.01*	0.54	3.13	5.30	57.21
"Khesari" ..	<i>Cicer arietinum</i> ..	9.98	28.22	0.57	2.99	..	58.24
Lentil ..	<i>Lens esculenta</i> ..	12.44	25.10	0.74	2.13	..	59.56
Peas, dried ..	<i>Pisum sativum</i> ..	16.03	19.68	1.14	2.12	4.50	56.53
Peas, roasted ..	Do. ..	9.90	22.94	1.39	2.34	..	63.43
"Rajmah" ..	..	12.03	22.89	1.31	3.22	..	60.55
"Rawan" ..	<i>Vigna catiang</i> ..	12.67	23.40	1.28	2.92	..	59.73
Red gram (Dhal arhar).	<i>Cajanus indicus</i>	15.23	22.27	1.71	3.56	..	57.23
Soya bean ..	<i>Glycine hispida</i> ..	8.08	43.22	19.50	4.63	3.72	20.85

* Sprouted pulses contain 10—15 milligrammes

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ * (Intern- ational units per 100 gms.).	Vita- min B ₂ .	Vitamin C mgs.* per 100 gms.	Remarks.
0.185	0.236	9.83	360.6	316	93	++	..	With outer husk.
0.067	0.311	8.89	372.4	..	..	..	..	Without outer husk.
0.213	0.603	9.88	414.6	..	..	..	..
0.200	0.367	9.80	358.7	64	140	++	..	Without outer husk.
0.073	0.485	3.81	327.5	60	..	++	..	
0.063	0.446	1.98	347.1	Trace	..	None	..	
0.143	0.281	8.40	342.8	158	155	++	..	With outer husk.
0.275	0.385	7.59	321.7	158	..	Poor	..	
0.107	0.496	5.63	351.0	..	..	..	..
0.130	0.250	1.98	345.4	450	150	+	..	
0.068	0.298	4.44	315.1	..	150	..	..
0.033	0.357	5.00	358.0	..	..	..	..
0.256	0.408	5.84	345.6	..	..	..	..
0.075	0.430	4.31	344.0	..	..	..	..
0.136	0.264	8.80	341.9	220	190	++	..	Without outer husk.
0.237	0.689	11.50	431.8	710	300	++	..	

of vitamin C per 100 grammes.

Leafy Vegetables.

Name of foodstuff.	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.
Amaranth, tender	<i>Amaranthus gangeticus</i> .	85.78	4.90	0.50	3.05	..	5.77
Amaranth, spined	<i>Amaranthus spinosus</i> .	85.00	3.00	0.25	3.61	..	8.14
Bamboo, tender shoots.	<i>Bambusa arundinacea</i> .	87.06	3.92	0.09	1.40	..	7.53
Brussels sprouts	<i>Brassica oleracea bullata gemmifera</i> .	84.57	4.68	0.46	1.02	..	9.27
Cabbage ..	<i>Brassica oleracea capitata</i> .	90.20	1.75	0.11	0.61	0.95	6.38
Celery ..	<i>Apium graveolens rapaceum</i> .	81.27	5.97	0.61	2.11	1.42	8.62
Coriander ..	<i>Coriandrum sativum</i> .	87.90	3.29	0.64	1.65	..	6.52
Curry leaves ..	<i>Murraya koenigii</i>	66.31	6.11	1.04	4.17	6.37	16.00
Drumstick ..	<i>Moringa oleifera</i> ..	74.98	6.65	1.73	2.27	0.87	13.50
Fenugreek ..	<i>Trigonella foenumgraecum</i> .	81.78	4.86	0.86	1.57	1.04	9.89
Garden Cress ..	<i>Lepidium sativum</i>	82.30	5.79	0.96	2.16	..	8.79
"Gogu" ..	<i>Hibiscus sabdariffa</i> .	86.22	1.70	1.07	1.02	..	9.99
Ipomoea ..	<i>Ipomoea reptans</i>	90.33	2.90	0.40	2.11	..	4.26
Lettuce ..	<i>Lactuca stiva</i> ..	92.94	2.05	0.26	1.18	0.53	3.04
Mint ..	<i>Mentha viridis</i> ..	82.99	4.81	0.59	1.56	1.95	8.10
Neem, mature ..	<i>Azadirachta indica</i>	59.44	7.09	1.04	3.36	6.19	22.88
Neem, tender ..	Do. ..	59.36	11.56	2.97	2.61	2.22	21.28
Parsley ..	<i>Petroselinum sativum</i> .	68.42	5.93	0.97	3.17	1.60	19.71
"Agathi" ..	<i>Sebania grandiflora</i> .	76.73	8.40	1.39	3.11	2.17	11.80
"Manthakkali"	<i>Solanum nigrum</i>	82.12	5.86	1.00	2.13	..	8.80
Spinach ..	<i>Spinacia oleracea</i>	91.66	1.92	0.85	1.50	..	4.07

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100. gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.560	0.160	21.40	47.2	2,500— 11,000.	29	+	172.9	
0.800	0.052	22.91	46.8	..	..	..	..
0.016	0.088	0.11	46.6	Trace	..	..	..
0.045	0.082	2.33	59.9	..	..	..	71.8	
0.034	0.046	0.76	33.5	2,000	50	..	124.2	
0.226	0.137	6.25	63.9	5,760 to 7,470.	Trace	..	62.4	
0.137	0.058	9.97	45.0	12,630	..	++	135.2	
0.811	0.057	3.09	97.8	12,600	..	++	4.2	
0.437	0.071	7.00	96.2	11,330	..			
0.472	0.047	16.90	66.7	3,860	..	..	..
0.359	0.113	28.57	67.0	..	50	..	..
0.181	0.038	5.38	56.4	..	..	..	..
0.113	0.048	3.90	32.2	3,270	29	..	137.1	
0.051	0.030	2.39	22.7	2,200	90	..	14.9	
0.204	0.077	15.56	57.0	2,700	..	..	..
0.514	0.080	17.14	129.2	..	..	..	..
0.124	0.189	25.30	158.1	4,560	..	..	..
0.392	0.195	17.86	111.3	3,200	..	..	280.8	
1.131	0.077	3.91	93.3	..	..	..	..
0.410	0.074	20.51	68.0	..	..	..	11.3	
0.061	0.010	4.95	31.6	2,630 to 3,000.	70	..	47.7	

Roots and Tubers.

Name of foodstuff.	Botanical name.	Mois- ture %.	Pro- tein %.	Fat (Ether Extrac- tives) %.	Mine- ral matter %.	Fibre %.	Carbohy- drate %.
Beet root ..	Beta vulgaris ..	83.81	1.65	0.05	0.75	..	13.74
Carrot ..	Daucus carota	86.00	0.92	0.07	1.08	1.18	10.75
Colocasia ..	Colocasia anti- quorum.	73.05	2.95	0.10	1.72	..	22.18
"Onthaligasu"		84.40	1.24	0.05	0.34	..	13.97
Parsnip ..	Pastinaca sativa	72.41	1.33	0.27	1.12	1.68	23.19
Potato ..	Solanum tuber- osum.	74.73	1.73	0.13	0.61	..	22.80
Radish (pink) ..	Raphanus sativus	90.76	0.61	0.32	0.85	..	7.46
Radish (White)	Do. ..	94.41	0.70	0.06	0.58	..	4.25
Sweet potato ..	Ipomoea batatas	66.51	1.24	0.32	1.04	..	30.89
Tapioca ..	Manihot utili- ssima.	59.37	0.68	0.20	0.98	..	38.77
Yam (elephant)	Amorphophallus Campanulatus.	78.79	1.24	0.02	0.82	0.80	18.33
Yam (ordinary)	Typhonium tri- lobatum.	69.90	1.41	0.09	1.55	..	28.46

Calcium (Ca) %.	Phos- Phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ (Intern- ational units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.195	0.057	0.98	62.0	0	70	..	<88	
0.082	0.030	1.52	47.3	2,020	60	..	2.5	
0.038	0.143	2.13	101.4	40	.	+	Trace	
0.013	0.024	0.53	61.3	..	..	..	..
0.048	0.041	0.40	100.5	30	105	..	16	
0.004	0.034	0.68	99.3	40	40	++	17.3	
0.046	0.017	0.47	35.2	} 3 }	} 60 }	..	16.9	
0.054	0.025	0.40	20.3			..	15.0	
0.017	0.050	0.79	131.4	10	..	++	24.0	
0.045	0.039	0.92	159.6	..	..	..	..
0.046	0.022	0.62	78.4	434	..	++	Trace	
0.061	0.016	1.30	120.3	..	24	..	Trace	

Other Vegetables.

Name of foodstuff.	Botanical name.	Mois- ture %.	Pro- tein %.	Fat (Ether Extrac- tives) %.	Mine- ral matter %.	Fibre %.	Carbohy- drate %.
Amaranth, stem	<i>Amaranthus gan- geticus.</i>	92.49	0.85	0.11	1.84	1.20	3.51
Artichoke ..	<i>Cynara scolymus</i>	77.27	3.64	0.14	1.75	1.20	15.93
Ash gourd ..	<i>Benincasa cerifera</i>	93.01	0.41	0.06	0.34	..	3.18
Bitter gourd ..	<i>Momordica cha- rantaia</i>	92.39	1.64	0.15	0.73	0.80	4.26
Bitter gourd (small variety).	Do. ..	83.16	2.87	0.98	1.43	1.70	9.86
Brinjal ..	<i>Solanum melon- gena.</i>	91.19	1.31	0.26	0.50	..	6.44
Broad beans ..	<i>Dolichos lablab</i> var. <i>lignosus.</i>	82.41	4.43	0.12	0.93	2.02	9.98
Calabash cucum- ber.	<i>Lagenaria vulgaris</i>	96.34	0.16	0.14	0.49	..	2.67
Cauliflower ..	<i>Brassica oleracea</i> <i>botrytes.</i>	59.43	3.51	0.41	1.36	..	5.29
"Cho-cho" marrow.	<i>Sechium edule</i> ..	92.53	0.70	0.11	0.41	..	6.25
Celery stalks ..	<i>Apium graveolens</i> <i>rapaceum.</i>	93.53	0.79	0.09	0.89	1.17	3.53
Cluster beans ..	<i>Cyamopsis psor- alioides.</i>	82.45	3.67	0.17	1.35	2.26	10.10
Colocasia stems	<i>Colocasia anti- quorum.</i>	93.44	0.34	0.34	1.20	0.59	4.09
Cucumber ..	<i>Cucumis sativus</i> ..	96.42	0.45	0.06	0.31	..	2.76
Double beans ..	<i>Faba vulgaris</i> ..	73.75	8.28	0.27	0.94	..	16.76
Drumstick ..	<i>Moringa oleifera</i> ..	86.88	2.53	0.11	1.96	4.80	3.72
French beans ..	<i>Phaseolus vulgaris</i>	91.43	1.74	0.11	0.53	1.80	4.39
Indian gooseberry	<i>Emblica officinalis</i>	81.21	0.52	0.09	0.68	3.42	14.08
Ipomoea, stems	<i>Ipomoea reptans</i>	93.67	0.83	0.20	1.76	..	3.54
Jack, tender ..	<i>Artocarpus integri- folia.</i>	84.01	2.61	0.31	0.91	2.78	9.38
Jack fruit seeds	Do. ..	51.60	6.00	0.36	1.54	1.45	38.45
"Kandan Kathiri"	<i>Solanum xantho- carpum.</i>	75.50	3.09	0.77	1.57	14.15	4.92
"Kovai" fruit, tender.	<i>Coccinia indica</i> ..	93.07	1.17	0.10	0.46	1.56	3.64
Knol-khol ..	<i>Brassica oleracea</i> <i>caulorapa.</i>	92.10	1.07	0.20	0.65	..	5.98
Ladies fingers ..	<i>Hibiscus esculentus</i>	87.95	2.20	0.20	0.74	1.15	7.70
Looks ..	<i>Allium porum</i> ..	78.91	1.84	0.10	0.68	1.32	17.15

Calcium (Ca) %	Phos- phorus (P) %	Iron (Fe) mgs. %	Calorific value per 100 gms.	Carotene (Inter- national Vita- min A units per 100 gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.263	0.034	1.80	18.4	..	..	..	..
0.120	0.101	2.59	79.9	..	75	..	Trace	
0.025	0.017	0.45	14.9	Trace	21	..	0.9	
0.023	0.065	2.22	25.0	} 210	} 24	Poor	} 88.4	
0.045	0.144	9.35	59.7					
0.024	0.064	1.31	33.3	5	..	+	22.5	
0.045	0.055	1.81	59.0	..	..	..	12.2	
0.015	0.003	0.69	13.4	Trace	..	..	..
0.034	0.061	1.25	38.9	38	110	..	65.8	
0.128	0.026	0.62	28.8	Trace	..	..	..
0.033	0.038	4.76	18.1	..	..	..	5.7	
0.120	0.051	5.76	56.6	330	..	..	49.4	
0.062	0.024	0.50	20.8	..	..	..	..
0.012	0.025	1.48	13.4	Trace	30	..	6.9	
0.036	0.142	2.27	102.6	..	..	..	22.4	Seeds only.
0.032	0.111	5.28	26.0	184	..	..	119.6	
0.048	0.025	1.67	25.5	221	26	..	13.8	
0.045	0.019	1.23	59.2	..	..	..	..
0.081	0.027	0.78	19.3	..	..	..	..
0.026	0.043	1.66	50.8	..	..	..	..
0.049	0.133	0.16	183.4	..	..	..	..
0.100	0.091	1.22	39.0	..	..	..	..
0.037	0.030	1.35	20.1	260	..	..	28.0	
0.023	0.035	0.40	30.0	..	..	..	84.5	
0.094	0.078	1.54	41.0	58	21	+	15.6	
0.052	0.073	2.30	76.9	..	75	..	10.7	

Other Vegetables—*contd.*

Name of foodstuff.	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.
Mango, green ..	<i>Mangifera indica</i>	90.03	0.65	0.11	0.37	..	8.84
Nut of Avocado pear.	<i>Persea drymifolia</i>	63.67	2.52	0.71	1.10	..	32.00
Onion, stalk ..	<i>Alium cepa</i> ..	87.64	0.94	0.24	0.77	1.60	8.81
Peas, English ..	<i>Pisum sativum</i> ..	72.09	7.18	0.12	0.75	..	19.86
Pink beans ..	<i>Phaseolus vulgaris</i>	88.49	2.44	0.18	0.58	2.10	6.21
Plantain flower	<i>Musa paradisiaca</i>	90.22	1.45	0.19	1.21	1.93	5.00
Plantain, green	Do. ..	83.24	1.41	0.23	0.51	..	14.61
Plantain stem	Do. ..	88.26	0.48	0.05	0.61	0.76	9.84
Pumpkin ..	<i>Cucurbita maxima</i>	92.60	1.36	0.07	0.58	..	5.39
Rhubarb stalks	<i>Rheum Rhaponticum</i> .	92.74	1.10	0.51	1.05	0.85	3.75
Ridge gourd ..	<i>Luffa acutangula</i>	95.43	0.52	0.12	0.34	..	3.59
"Singhara" or water chestnut.	<i>Trapa bispinosa</i>	70.01	4.67	0.29	1.07	..	23.96
Snake-gourd ..	<i>Trichosanthes anguina</i> .	94.06	0.46	0.31	0.70	..	4.47
Spinach stalks	<i>Spinacia oleracea</i>	93.37	0.87	0.14	1.82	..	3.80
"Sundakai", dry	<i>Solanum torvum</i>	12.25	8.31	1.66	5.09	17.58	55.11
Tomato, green	<i>Lycopersicum esculentum</i> .	92.81	1.88	0.06	0.68	..	4.57
Turnip ..	<i>Brassica rapa</i> ..	91.10	0.52	0.23	0.60	..	7.52
Vegetable marrow	<i>Cucurbita pepo</i> ..	94.84	0.48	0.09	0.27	..	4.32

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ (Intern- ational units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.012	0.017	4.48	39.0	150	..	..	3.2	
0.018	0.083	1.19	144.5	..	..	..	..
0.048	0.054	7.50	41.2	..	..	..	..
0.019	0.078	1.47	109.2	139	120	..	9.2	
0.035	0.039	1.24	36.2	..	..	..	<27.7	
0.034	0.048	0.12	27.5	..	..	..	..
0.005	0.027	0.60	66.2	50	15	++	23.9	
0.009	0.005	1.06	41.7	..	..	..	..
0.009	0.030	0.67	27.6	84	20	..	2.0	
0.119	0.012	2.20	24.0	..	0	..	36.7	
0.035	0.040	1.68	17.5	56	22	..	..
0.024	0.154	0.82	117.1	20	..	..	..
0.045	0.024	1.28	22.5	160	..	..	Trace	
0.090	0.015	1.34	19.9	..	..	..	2.9	
0.370	0.179	22.22	268.6	750	..	..	..
0.016	0.039	2.37	26.3	320	23	..	31.3	
0.028	0.035	0.42	34.2	Trace	40	..	43.4	
0.002	0.026	0.63	20.0	Trace	..	..	17.8	

Nuts and Oil Seeds.

Name of foodstuff.	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.
Almond ..	<i>Prunus amygdalis</i>	5.23	20.75	58.92	2.90	1.70	16.50
Cashew nut ..	<i>Anacardium occidentale</i> .	5.89	21.19	46.93	2.43	1.27	22.29
Coconut ..	<i>Cocos nucifera</i> ..	36.28	4.47	41.60	0.96	3.59	13.19
Gingelly seeds ..	<i>Sesamum indicum</i>	5.08	18.33	43.26	5.20	2.88	25.25
Ground-nut ..	<i>Arachis hypogea</i>	7.92	26.72	40.13	1.87	3.07	20.29
Ground-nut, roasted.	Do. ..	4.04	31.54	39.76	2.28	3.07	19.31
Linseed (seeds) ..	<i>Linum usitatissimum</i> .	6.57	20.27	37.11	2.44	4.80	28.81
Mustard seeds ..	<i>Brassica juncea</i> ..	8.46	22.04	39.64	4.19	1.80	23.87
Pistachio nut ..	<i>Pistacia vera</i> ..	5.58	19.81	53.51	2.75	2.10	16.25
Walnut ..	<i>Juglans regia</i> ..	4.53	15.64	64.49	1.34	2.60	10.90

Fats and oils of vegetable origin derived from oilseeds, etc., are in general devoid

Calcium (Ca) %	Phos- phorus (P) %	Iron (Fe) mgs. %	Calorific value per 100 gms.	Carotene (Inter- national Vita- min A units per 100 gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.225	0.492	3.47	655.3	..	80	..	..
0.053	0.449	4.95	596.3	100	..	+	..	
0.013	0.243	1.70	444.7	Trace	Trace	Poor	0.8	
1.453	0.574	10.54	563.7	107	..	..	..
0.048	0.392	1.56	549.2	63	300	+	..	
0.045	0.435	0.29	561.2	..	..	..	..
0.173	0.371	2.65	530.3	..	..	..	..
0.488	0.704	17.88	540.4	270	..	..	Trace.	
0.136	0.431	13.70	625.8	..	..	..	..
0.095	0.384	4.76	686.6	..	150	..	..

of carotene and vitamin A. Red palm oil is an exception (see p. 5).

Condiments, Spices, etc.

Name of foodstuff.	Botanical name.	Mois- ture %.	Pro- tein %	Fat (Ether Extrac- tives) %.	Mine- ral matter %.	Fibre %.	Carbohy- drate %.
" Arisithippili "	<i>Piper clusii</i> ..	12.53	13.24	4.66	6.03	5.17	58.37
Asafoetida ..	<i>Ferula narthex</i> ..	16.03	3.95	1.13	6.99	4.12	67.78
Cardamom ..	<i>Elettaria carda- momum.</i>	19.95	10.21	2.18	5.37	20.10	42.19
Chillies, green ..	<i>Capsicum annum</i>	82.60	2.87	0.59	1.04	6.73	6.17
Chillies, dry ..	Do. ..	10.02	15.88	6.24	6.10	30.15	31.51
Cloves ..	<i>Eugenia caryo- phyllata.</i>	23.29	5.24	8.90	5.20	9.54	47.83
Coriander ..	<i>Coriandrum sa- tivum.</i>	11.15	14.08	1.04	4.39	32.58	36.76
Cumin ..	<i>Cuminum cymi- num.</i>	11.94	18.71	0.58	5.84	11.98	50.95
Fenugreek seeds	<i>Trigonella foenum- graceum.</i>	13.70	26.19	5.77	3.00	7.16	44.18
Garlic ..	<i>Allium sativum</i> ..	62.79	6.31	0.13	1.02	0.80	28.95
Ginger ..	<i>Zingiber officinale</i>	80.86	2.33	0.94	1.19	2.42	12.26
" Kandanthip- pili."	<i>Piper roxburghii</i>	12.24	6.44	2.32	4.77	8.51	65.72
Mace ..	<i>Myristica fragrans</i>	15.92	6.51	24.36	1.58	3.76	47.87
Mustard ..	<i>Brassica juncea</i> ..	8.46	22.04	39.64	4.19	1.80	23.87
Nutmeg ..	<i>Myristica fragrans</i>	14.32	7.49	36.44	1.72	11.59	28.44
Omum ..	<i>Carum copticum</i>	8.92	15.41	18.08	7.09	11.87	38.63
Onion, big ..	<i>Allium cepa</i> ..	86.76	1.22	0.04	0.36	..	11.62
Onion, small ..	Do. ..	84.33	1.80	0.08	0.55	..	13.24
Pepper, dry ..	<i>Piper nigrum</i> ..	12.86	11.53	6.79	4.40	14.92	49.50
Tamarind ..	<i>Tamarindus indi- cus.</i>	20.86	3.06	0.14	2.86	5.57	67.51
Turmeric ..	<i>Curcuma longa</i> ..	13.08	6.33	5.10	3.51	2.60	69.38

Calcium (Ca) %	Phos- phorus (P) %	Iron (Fe) mgs. %	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.462	0.278	13.54	328.4	..	..	..	..
0.692	0.045	22.20	297.1	..	..	..	..
0.128	0.163	5.00	229.2	..	..	..	..
0.029	0.079	1.31	41.5	454	..	..	111.0	
0.163	0.371	2.25	245.7	576	..	..	51.2	
0.739	0.097	4.90	292.4	..	..	..	..
0.630	0.366	17.94	212.7	1,570	..	..	Trace.	
1.083	0.487	31.00	283.9	870	..	..	3.0	
0.157	0.365	14.10	333.4	160	..	..	..
0.025	0.305	1.31	142.2	0	..	..	13.2	
0.016	0.063	2.57	66.8	67	..	..	6.0	
1.225	0.188	62.10	309.5	..	..	..	..	Roots only.
0.181	0.103	12.64	436.8	..	..	..	..
0.488	0.704	17.88	540.4	270	..	..	Trace	
0.122	0.235	4.57	471.7	..	..	..	..
1.422	0.297	14.62	379.9	..	..	..	..
0.176	0.046	0.66	51.7	..	} 40	..	} 10.5	
0.040	0.058	1.18	60.9	25		..		..
0.460	0.199	16.80	305.2	..	..	..	..
0.172	0.110	10.90	283.5	100	..	..	2.6	Pulp only.
0.146	0.284	18.60	348.7	50	..	..	..

Fruits.

Name of foodstuff.	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.
Apple ..	<i>Pyrus malus</i> ..	85·94	0·31	0·08	0·27	..	13·40
Banana ..	<i>Musa sapientum</i>	61·39	1·33	0·15	0·72	..	36·41
Bullock's heart	<i>Anona reticulata</i>	76·79	1·39	0·16	0·74	..	20·92
Cape goose-berry	<i>Physalis peruviana</i>	82·69	1·78	0·17	0·59	3·19	11·58
Dates (Persian)	<i>Phoenix dactylifera</i> .	26·11	3·04	0·16	1·31	2·07	67·31
Figs ..	<i>Ficus carica</i> ..	80·80	1·31	0·23	0·64	..	17·02
Grapes (Blue variety).	<i>Vitis vinifera</i> ..	85·51	0·83	0·10	0·43	3·00	10·13
Grape fruit (Triumph).	<i>Citrus grandis</i> var. <i>maxima</i> .	92·04	0·71	0·03	0·20	..	7·02
Grape fruit (Marsh's seedless).	Do. ..	88·51	0·95	0·06	0·35	..	10·13
Guava, country	<i>Psidium guajava</i>	76·07	1·46	0·19	0·81	6·90	14·57
Guava, Hill ..	<i>Psidium catelium</i> .	85·31	0·95	0·16	0·61	4·82	8·15
Jack fruit ..	<i>Artocarpus integrifolia</i> .	77·20	1·86	0·10	0·78	1·09	17·88
Jambu fruit ..	<i>Eugenia jambos</i>	78·21	0·67	0·10	0·41	0·87	19·74
"Korukkapalli"	<i>Pithecolobium dulce</i> .	80·78	2·57	0·31	0·41	..	15·93
Lemon ..	<i>Citrus medica</i> var. <i>limonum</i> .	84·97	0·98	0·85	0·26	1·65	11·29
Lime ..	<i>Citrus medica</i> var. <i>acida</i> .	84·57	1·49	0·97	0·64	1·25	11·08
Mango, green ..	<i>Mangifera indica</i>	90·03	0·65	0·11	0·37	..	8·84
Mango, ripe ..	Do. ..	86·14	0·64	0·07	0·32	1·14	11·66
Mango, "Ankola"	Do. ..	85·94	1·02	0·11	0·46	..	12·46
Melon, water ..	<i>Citrullus vulgaris</i>	95·70	0·12	0·15	0·22	..	3·81
Orange ..	<i>Citrus aurantium</i>	87·84	0·85	0·32	0·43	..	10·56
Palmyra fruit, tender.	<i>Borassus flabellifer</i>	92·72	0·58	0·02	0·17	..	6·51

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- nation- al Vita- min A units per 100 gms.).	Vitamin B ₁ (Internat- ional units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.013	0.021	1.68	55.0	Trace	40	..	2.1	
0.002 ^p	0.045	0.42	147.6	Trace	50	..	1.0	
0.014	0.009	0.63	90.7	..	..	..	..
0.006	0.058	1.80	55.0	..	..	..	49.0	
0.067	0.076	10.58	282.8	600	30	+	Trace	Preserved fruits.
0.055	0.026	1.16	75.4	..	..	..	2.4	
0.025	0.019	0.40	44.7	15	Trace	..	2.5	
0.017	0.021	0.18	31.2	..	} 40	} ..	31.2 (Juice).	
0.025	0.027	0.20	44.9	..				
0.013	0.040	1.04	65.8	100	..	..	290.0	
0.046	0.022	1.20	37.8	..	..	..	15.0	
0.022	0.028	0.46	79.9	540	..	..	10	
0.016	0.011	1.00	82.5	..	..	..	..
0.011	0.036	0.37	76.8	..	..	..	..
0.070	0.014	2.33	56.7	..	..	..	38.5 (Juice).	
0.091	0.021	0.29	59.0	120	..	..	62.5 (Juice).	
0.012	0.017	4.48	39.0	150	..	..	3.2	
0.007	0.020	0.25	50.0	4,800	..	Poor	..	
0.004	0.016	0.45	55.0	1,860	..	..	23.6	
0.001	0.008	0.15	17.1	Trace	..	..	1.0	
0.046	0.022	0.08	48.5	350	40	..	67.7	
0.005	0.021	0.46	28.5	..	..	..	..

Fruits—contd.

Name of foodstuff.	Botanical name.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.
Papayya, ripe ..	<i>Carica papaya</i> ..	89·62	0·47	0·03	0·38	..	9·50
Peaches ..	<i>Amygdalis persica</i>	90·07	1·52	0·19	0·58	..	7·64
Pears, country ..	<i>Pyrus communis</i> ..	86·92	0·18	0·05	0·27	1·00	11·58
Pears, English ..	<i>Pyrus Achras</i> ..	85·84	0·94	0·23	0·23	..	12·76
Pears, Avocado or Butter fruit.	<i>Persea drymifolia</i>	73·55	1·68	22·81	1·05	..	0·91
Pine apple ..	<i>Ananas sativus</i> ..	86·50	0·57	0·04	0·49	0·40	12·00
Plantain (Ordinary).	<i>Musa paradisiaca</i>	73·35	1·06	0·08	0·72	..	24·79
Plantain, Hill "Anaikombu"	<i>Musa paradisiaca</i>	79·93	1·22	0·06	0·80	..	17·99
Plums (Red variety).	<i>Prunus domestica</i>	89·82	0·68	0·22	0·36	..	8·92
Pomegranate ..	<i>Punica granatum</i>	78·00	1·63	0·04	0·67	5·10	14·56
Pomeloe ..	<i>Cirtus decumana</i>	88·10	0·63	0·04	0·51	0·60	10·12
Quince ..	<i>Cydonia vulgaris</i>	85·76	0·28	0·04	0·33	1·72	11·87
Raisins (preserved).	<i>Vitis vinifera</i> ..	18·47	1·96	0·18	1·98	..	77·41
Strawberry ..	<i>Fragaria grandiflora</i> .	87·82	0·71	0·18	0·38	1·14	9·77
Tomato, ripe ..	<i>Lycopersicum esculentum</i> .	94·52	1·02	0·08	0·48	..	3·90
Tree Tomato ..	<i>Cyphomandra betacea</i> .	82·72	1·46	0·21	1·12	4·15	10·34
Wood apple ..	<i>Feronia elephantum</i> .	69·54	7·31	0·56	1·88	5·16	15·55
Tamarind ..	<i>Tamarindus indicus</i> .	20·86	3·06	0·14	2·86	5·57	67·51

Calcium (Ca) %.	Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (Inter- national Vitamin A units per 100 gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.013	0.009	0.42	40.2	2,020	..	..	45.5	
0.006	0.029	1.70	38.4	Trace	..	..	1.0	
0.006	0.011	0.68	47.5	14	..	..	Trace	
0.005	0.016	0.84	56.9	80	30	..	1.0	
0.011	0.076	0.71	215.7	..	..	..	13.0	
0.021	0.007	0.92	50.6	98	..	..	62.9	
0.011	0.031	0.50	104.1	124	..	Poor	5.5	
0.007	0.025	0.27	77.4	124	..	..	8.5	
0.017	0.018	0.55	40.4	230 (Yellow variety).	40	..	0.6	
0.009	0.066	0.27	65.1	0	..	..	15.6	
0.028	0.027	0.04	43.4	200	..	..	..
0.005	0.015	0.44	49.0	..	..	..	10.0	
0.101	0.075	3.98	319.1	..	75	..	Trace	
0.026	0.026	1.75	43.5	..	..	..	52.6	
0.008	0.018	0.08	20.4	320	40	..	32.2	
0.013	0.029	0.71	43.3	..	..	..	Trace	
0.127	0.107	0.62	96.5	..	..	..	..
0.172	0.110	10.90	283.5	100	..	..	2.6	

Flesh Foods.

Name of food-stuff.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.	Calcium (Ca) %.
Beef (muscle) ..	74.33	22.61	2.58	0.99	..	..	0.004
Crab (muscle) ..	83.49	8.87	1.07	3.20	..	3.37	1.370
Egg, duck ..	71.00	13.54	13.72	1.03	..	0.70	0.073
Egg, fowl ..	73.65	13.33	13.32	0.95	..	..	0.056
Fish (Mangalore, big fish).	78.38	22.60	0.06	0.83	..	..	0.020
Fish, (Mangalore, small fish).	77.89	21.49	1.63	2.03	..	..	0.055
Fish, "Vajra" ..	79.41	19.92	1.51	1.38	..	..	0.044
Liver, sheep ..	70.37	19.29	7.49	1.45	..	1.40	0.006
Mutton (muscle) ..	71.46	18.54	13.30	1.26	..	..	0.147
Pork (muscle) ..	77.41	18.66	4.40	1.01	..	..	0.034
Prawn (muscle) ..	77.94	20.84	0.28	1.42	..	..	0.088

Phosphorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Vitamin A (International units per 100 gms.).	Carotene. (International Vitamin A units per 100 gms.).	Vitamin B ₁ (International units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.190	0.77	113.7	59.0	0	50	++	..	
0.147	21.20	58.6	Trace	1,300	..	..	..
0.261	2.97	180.4	1,233	..	..	..	..
0.271	2.07	173.2	1,197	1,000	..	..	..
0.185	0.83	90.9	} 25.6	} 9.0	..	} Poor	..	Types of fish commonly consumed in Malabar.
0.413	2.28	100.6						
0.379	0.72	93.3						
0.378	6.30	150.2	22,308	0	120	..	..
0.151	2.52	193.9	30.8	0	60	..	..
0.198	2.27	114.2	Trace	..	320	..	..
0.244	0.79	85.9	Trace	Trace	<30	..	..

Milk and Milk Products.

Name of food-stuff.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.	Calcium (Ca) %.
Milk, cow's ..	87.60	3.30	3.60	0.70	..	4.80	0.120
Milk, buffalo's ..	82.30	4.75	7.70	0.80	..	4.45	0.203
Milk, goat's ..	86.30	3.60	4.00	0.80	..	5.30	0.128
Milk, human ..	87.58	1.18	3.74	0.30	..	7.20	0.034
Butter-milk ..	97.54	0.84	1.08	0.14	..	1.40	0.030
Curds ..	90.31	2.86	2.94	0.59	..	5.30	0.120
Skim milk powder	4.10	38.04	0.09	6.83	..	50.94	1.370
Cheese ..	40.30	24.10	25.10	4.20	..	6.30	0.786

Phosphorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Vitamin A (International units per 100 gms.).	Carotene (International Vitamin A units per 100 gms.).	Vitamin B ₁ (International units per 100 gms.).	Vitamin B ₂	Vitamin C mgs. per 100 gms.	Remarks.
0.093	0.24	66.8	180	0	..	++	..	
0.125	..	106.1	162	0	..	..	..
0.103	..	71.6	182	0	..	..	..
0.015	..	67.2	208	0	..	..	..
0.030	0.78	18.7	0	0	..	++	..	
0.088	0.31	59.1	Trace	Trace	..	++	..	
0.995	1.43	356.7	0	0	165	+++	..	
0.524	2.10	347.5	273	..	..	..	..

Miscellaneous Foodstuffs.

Name of food-stuff.	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.	Calcium (Ca.) %.
Betel leaves (<i>Piper betel</i>).	85.41	3.07	0.80	2.25	2.33	6.14	0.227
Jaggery ..	3.93	0.36	0.06	0.62	..	95.03	0.075
"Pappads" ..	20.32	18.76	0.33	8.17	..	52.42	0.080
"Perandai" (<i>Vitis quadrangularis</i>).	87.42	1.21	0.34	2.01	1.83	7.19	0.651
Sweet toddy ..	84.72	0.10	0.17	0.66	..	14.35	0.149
Cod liver oil	..	..	100.0	..	..	..	..
Halibut liver oil ..	..	..	100.0	..	..	..	..
Red Palm oil (<i>Elaeis guineensis</i>).	..	..	100.0	..	..	..	..

Phos- phorus (P) %.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Vitamin A (Inter- national units per 100 gms.).	Caro- tene. (Inter- national Vitamin A units per 100 gms.).	Vitamin B ₁ (Inter- national units per 100 gms.).	Vitamin B ₂ .	Vitamin C mgs. per 100 gms.	Remarks.
0.044	5.74	44.0	0	9,635	..	..	4.8	
0.038	11.40	382.1	..	280	..	..	..
0.298	17.24	287.7	..	Trace	..	..	..
0.050	2.12	36.7	..	..	..	..	..
0.011	0.26	59.3	..	..	..	Poor	..	
..	..	900.0	45,000 to 168,000.	0	..	..	..
..	..	900.0	3,900,000	0	..	..	..
..	..	900.0	0	44,000	..	..	..

APPENDIX II.

Table showing the percentage of "available" iron in certain foodstuffs.

Foodstuff.	Percent of "available" iron.
Wheat	47
Oats	57
Yeast	47
Lima beans	72
Navy beans	61
Peas (canned)	90
Peas (fresh)	72
Soya bean (roasted)	60
Soya bean (non-roasted)	80
Parsley (dry)	23
Lettuce	25
Spinach (fresh)	19
Spinach (dry)	20
Raisins (bleached, seedless)	30
Raisins (Muscat)	62
Apricots	50
Almonds	88
Bananas	61
Alfalfa	27
Oysters (dry)	25
Beef, skeletal muscle (dry)	50
Beef heart muscle (dry)	70
Pork heart muscle (dry)	86
Beef liver (dry)	70
Pork liver (dry)	66
Beef kidney	40



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INTRODUCTORY NOTE.

This Bulletin has been prepared in the Nutrition Research Laboratories, Coonoor, which are financed by the Indian Research Fund Association. The Nutrition Advisory Committee of the Indian Research Fund Association considered the Bulletin at its meeting in December 1939, and approved of it. The Bulletin is essentially a popular summary of a scientific publication entitled "The Rice Problem in India"* which may be consulted by those who wish to study the scientific aspects of the subject in greater detail.

*Indian Medical Research Memoir No. 32 (Thacker, Spink and Co. (1933), Ltd., Calcutta, price Rs. 3-8-0).

HEALTH BULLETIN

RICE.

(1) *The production and consumption of Rice.*

Rice and wheat are the two most important cereals in the world, the total annual production of each being over a hundred thousand million pounds (45,000,000,000 kilograms). It has been estimated that some 700 million people, or approximately half the world's population, live on rice as their staple cereal. Eastern Asia is the great centre of rice production; China, Japan, Indo-China, the Philippine Islands, the Netherlands East Indies, Burma and India are together responsible for about 90 per cent. of the entire production of the world. The prominence of rice as a food crop in India and Burma is shown by the available statistics, which include data about the area under rice and estimates of annual production based on the area sown and the average yields in each locality. Table 1 shows the position which rice occupies among the various important food crops in British India.

TABLE 1.

Area under different grain crops, 1936-37 (British India).

(Millions of acres).

Rice	81.7
Wheat	25.3
Jowar or cholam (<i>Sorghum vulgare</i>)	24.0
Pulses	15.8
Bajra or cambu (<i>Pennisetum typhoideum</i>).	11.5
Barley	6.5
Maize	6.0
Ragi (<i>Eleusine coracana</i>)	3.6

(From the "Statistical Abstract of British India 1936-37").

The total area under rice is about 33 per cent. of the total area sown and about 3 times as much as that under wheat, the cereal which comes next in extent of cultivation.

Table 2 shows the relative importance of rice in various Indian Provinces and also in Burma. Broadly speaking, it is the predominant crop in the eastern parts of India adjacent to the Bay of Bengal, from Cape Comorin in the south to Burma in the north-east. In Eastern Madras, Orissa, Bengal and Assam more than 75 per cent. of the total food crops sown consists of rice. Inland, away from the coastline towards the west and north, the production of rice relative to that of other cereals gradually decreases. In the Punjab, Sind, and the North-West Frontier Province, rice is grown in smaller quantities and though important in certain areas forms a much smaller proportion of the total agricultural production.

TABLE 2.

Rice production in the various Provinces.

	Population (millions) (1931)	Acres under rice (millions) (1936-37).	Percentage of total area under grain.	Yield million tons. (1936- 37).	Oza. of rice available per head per day.
Assam	8.6	5.4	95	1.9	19
Bengal	50.1	22.0	93	9.8	14
Bihar and Orissa	37.7	15.1	57	5.0	9
Bombay and Sind	21.9	3.1	12	1.1	5
Burma	14.7	12.6	86	4.7	33
Central Provinces and Berar	15.5	5.7	28	1.8	9
Madras	46.7	9.9	40	4.8	10
North-West Frontier Province	2.4	Negligible	Negligible	..	..
Punjab	23.6	1.0	4	..	..
United Provinces	48.4	6.8	16	1.9	4

(From the Indian Year Book 1937-38, and the "Statistical Abstract of British India," 1936-37.)

Little change in the total area under rice appears to have taken place within recent years. But the use of "improved" or high-yielding varieties, produced or standardised in agricultural research institutes, has been spreading. Such varieties may give increased yields varying from 10 to 30 per cent. In all probability, the results of agricultural research will in the future be passed on to the cultivator with increasing effectiveness, so that we may expect that more and more land will be sown with high-yielding varieties. In this way a substantial increase in the total yield of rice may be expected in the next few decades. The areas under "improved" varieties in various provinces and in Burma in 1936-37 are shown in Table 3.

TABLE 3.

"Improved" rice crops.

	Area under "improved" rice crops (1937-38) (million acres.)	Approximate percentage of total area under rice.
Madras	1.78	13.0
Burma	1.14	9.0
C. P. and Berar	0.70	12.0
Bengal	0.50	3.5

(Data supplied by Imperial Council of Agricultural Research.)

No province in India ordinarily produces rice in excess of its own requirements. While there is some internal trade between provinces, little rice is available for foreign export. Burma is differently situated in this respect. There is a considerable export trade from Burma to the Madras Presidency, and this has been steadily increasing within recent years. In 1935-36 imports

exceeded a million tons, a figure equivalent to about 20 per cent. of the total consumption of the Presidency. The import and export trade in rice between Madras and other parts of India, and foreign countries other than Burma, is negligible in comparison with total consumption.

The production of rice in husk in Madras for the period 1928-33 was some 430,000 tons more than production in the period 1918-23, an increase of approximately 2 per cent. From 1921-31, 4.4 millions were added to the population, an increase of approximately 10 per cent. It is thus probable that the rice-eating population of Madras is increasing more rapidly than rice production and that the gap between internal production and requirements is being filled by increasing imports.

(2) *The rice problem.*

The nutritive value of rice is a question of great interest and importance because rice is the staple food of a large proportion of mankind. Another reason is that serious disease may be caused by eating a diet largely composed of milled rice. The association between the disease called beri-beri and milled rice was established 25 years ago by workers in Eastern countries. It was discovered that beri-beri is caused by insufficient intake of a vitamin which is present in abundant quantities in the outer layers of rice and other food grains, but in much smaller quantities in the inner starchy kernel which is all that remains when rice is highly milled. This vitamin is known as vitamin B₁.

Beri-beri is a common disease in certain parts of India and its prevention is an important aspect of the rice problem. But there are other aspects which need consideration. First, rice has certain defects as a food even when it has not been deprived of the more nutritious outer layers by milling. Secondly, highly milled rice differs from under-milled rice in other respects besides its content of the anti-beri-beri vitamin. Thirdly, the process of parboiling, commonly practised in India, brings about changes in the grain which are of great importance from the standpoint of nutrition. We shall deal with all these questions in this Bulletin.

The rice problem in the East has been discussed at various international conferences within the last 20 years. The Far Eastern Association of Tropical Medicine has considered it at various meetings and made pronouncements about the danger of consuming highly milled rice and recommended measures to discourage its use. It cannot be claimed that much progress has been made as a result. The League of Nations Intergovernmental Conference of Far Eastern Countries on Rural Hygiene, held in Java in 1937, took up the question again and passed the following resolution :

“The degree of milling to which rice is subjected is of vital importance in connection with the problem of nutrition throughout the East. In many countries, the poorer classes consume foods other than rice in small quantities, and it is very difficult, for economic reasons, to increase the amount of supplementary foods in the diet ; in such circumstances, the nutritive value of the main article of food, which is influenced by the degree of milling, becomes of great significance. The Conference recommends that only under-milled rice should be supplied in Government institutions. Efforts to popularise the use of under-milled rice by education and propaganda should be increased. It deploras the increasing tendency of urban and rural populations in the East to consume highly milled rice. It strongly recommends that Governments should make a thorough investigation of the nutritional, commercial, economic

and psychological aspects of the problem, attention being given to the possibility of checking the spread of mechanical rice mills in rural areas, with a view to conserving the healthy habit of consuming home-pounded rice, and to means of making under-milled rice easily available everywhere for those who wish to purchase it."

Beri-beri was not specifically mentioned in the Conference's recommendation. Emphasis was laid rather on the general nutritive value of rice and its importance.

Finally, the Nutrition Advisory Committee of the Indian Research Fund Association, at its meeting in November 1937, recommended that investigations along the lines suggested by the Java Conference should be undertaken in India. This has been done and the present Bulletin is largely based on the results of these investigations.

The rice-eater's diet.

The recommendation of the League of Nations Conference quoted above includes the statement that "in many countries, the poorer classes consume food other than rice in small quantities." This is certainly true as regards India and exact figures exist to prove it. Within recent years, dietary surveys have been carried out on sample groups of families in various parts of India which provide information about the foods consumed by the poor and the amount of each. Table 4, which includes the results of surveys in widely separated areas, gives a picture of the poor rice-eater's diet.

TABLE 4.

Mean daily intake of various foodstuffs in groups of families surveyed in various parts of India (Ozs. per adult man daily).

	Madras (Rural area).	Madras (Urban area).	Madras (Tea planta- tion labour- ers).	Bengal (Rural area).	Assam (Rural area).	Oriasa (Rural area).	Central Pro- vinces (Rural area).	Bombay City.
Rice	15.0 (millets 2.0)	14.2	18.0	25.0	19.4	19.0	26.0	16.2
Pulses	0.5	0.9	1.0	0.4	0.9	1.0	1.1	2.6
Leafy vegetables	0.3	0.6	none	0.2	0.8	1.4	1.5	1.9
Non-leafy vegetables }	0.9	2.8	3.0	7.0	4.0	6.0	3.0	5.7
Vegetable fats and oils	0.1	0.5	0.5	0.3	0.3	0.3	0.2	1.4
Fish, meat and eggs	0.8	1.5	1.5	0.7	0.7	0.6	negligible	0.9

Most of the surveys, the results of which are shown in the Table, were carried out on village families. The families included in the Madras (urban area) survey were weavers in the suburb of Saidapet. The Bombay City figures are taken from a report published by Professor S. P. Niyogi and Mr. D. R. Sukhatankar (Indian Medical Gazette, November 1939, p. 674). The group in question (Deccani community) included office peons, laboratory servants and industrial workers. A small quantity of milk (0.6 ozs. per adult man daily) was consumed by these families.

Condiments and spices in small quantities were included in the diets. Most groups also consumed gur or sugar in small amounts.

A striking fact about these diets is their close similarity. Other surveys, carried out in widely separated areas from Kashmir in the north to the Trichinopoly district in the south, have shown that the diet of the poor rice-eater is astonishingly uniform throughout India. The great bulk of his diet is composed of rice, which provides 80—90 per cent. of its total energy value. Only relatively small quantities of other foods such as pulses, vegetables, fruits and meat are included. Milk and milk products are taken by the poorer classes in rice-eating areas in negligible quantities or not at all.

With this picture in mind, we can appreciate the statement of the League of Nations Conference that "the nutritive value of the main article of food, which is influenced by the degree of milling, is of great significance." If typical rice diets in India included plenty of milk, ghee, vegetables, fruit and other foods, then the state in which rice is consumed would be of much less importance. But since this is far from being the case, we must pay close attention to the nutritive value of the staple itself.

The nutritive value of rice.

Protein is one of the most important constituents of food since it is necessary for the growth, maintenance and repair of the tissues. Rice, as compared with most other cereals, has a low protein content; it contains 6.7 grammes of protein per 100 grammes, whereas wheat, for example, contains considerably more. But experiments have shown that rice proteins have a fairly high "biological value", which means that they can fulfil the needs of the body with reasonable efficiency and are required in smaller amounts than proteins of lower "biological value." For this and other reasons deficiency of protein is not one of the important defects of typical rice diets.

Rice, like other cereals, is poor in fat. Typical rice diets may supply less than 20 grammes of fat daily, whereas an intake of 60 grammes or more is often recommended. But we do not know exactly how much fat human beings require, and there is no evidence that a low consumption of fat produces ill effects. We need not condemn rice as a food because it contains little fat.

Of greater importance is its low content of vitamin A, a substance which the body must obtain in sufficient quantities if health is to be maintained. The rice-eater must rely on foods other than rice for an adequate supply of vitamin A, and often his diet is so limited in variety that he does not obtain it. Disease due to vitamin A deficiency is common in India. An example is the destructive eye disease called keratomalacia, which is responsible for much blindness in South India and probably in other parts of the country.

The element calcium, which is required by the body for many purposes and in particular for bone formation, is one of the most important food factors. Rice is a poor source of calcium whatever the variety or state of milling. The poor rice-eater obtains from his staple food only about one-tenth of the amount of calcium he needs. The other foods he consumes are as a rule poor in calcium and insufficiency of calcium is one of the most serious faults of his diet.

Milling.

So far we have been considering characteristics of the rice grain which are not affected in any very serious degree by milling and other processes (washing and cooking) to which rice is subjected before consumption. The statements which have been made about protein content remain approximately true of rice in any shape or form. As regards fat, vitamin A and calcium, the initial amounts of these substances present in the untouched grain are so small in relation to human requirements, that any further losses occurring during preparation cannot be considered important.

Cereal grains are composed of 3 parts : the germ or embryo ; the outer layer or pericarp ; and the inner starchy kernel or endosperm, which provides a store of food for the growing embryo. The structure of the rice grain is shown in the figure.

The germ and the pericarp of cereal grains are richer in various nutritive materials than the endosperm. Their composition is thus altered by milling, which partially or completely removes the outer layers. The ease with which any cereal grain can be deprived of these layers is influenced by its shape, size and other factors. The shape and consistency of the rice grain are such that an almost complete separation can readily be brought about by simple mechanical means. Machine-milling as ordinarily practised deprives the grain of the germ and almost all its pericarp. The process of hand-pounding, which is still largely followed in many parts of India, does not remove the outer layers to the same extent. The germ is usually lost, but typical hand-pounded rice usually retains some 50—75 per cent. of its pericarp. The amount of pericarp removed depends on the vigour and duration of pounding ; it is possible, if pounding is sufficiently prolonged, to deprive rice of its outer layers almost as completely in this way as in the machine mill.

There is one process, widely used in India in preparing rice for consumption, which is never applied to other cereals, namely, parboiling. "Parboiling" means the steaming or boiling of rice in the husk after preliminary soaking. This splits the woody husk and makes its subsequent removal easier. Parboiled rice after soaking, steaming and drying is pounded or milled in the same manner as raw (unsteamed) rice. The origin of the practice of parboiling, which is found in India, but not in the great rice-eating countries of China and Japan, is obscure ; possibly it derives from an accidental discovery that the preliminary steaming of rice reduces the labour of pounding.

Striking changes are brought about in the nutritive value of rice by parboiling and since the majority of rice-eaters consume parboiled rice in preference to raw* (unsteamed) rice, these changes are of great practical importance. Briefly described, they are as follows : during the process of steaming some of the vitamins and other nutritive substances contained in the germ and pericarp diffuse through the grain and cannot be removed by subsequent milling. Milled parboiled rice has thus a higher nutritive value than milled raw rice.

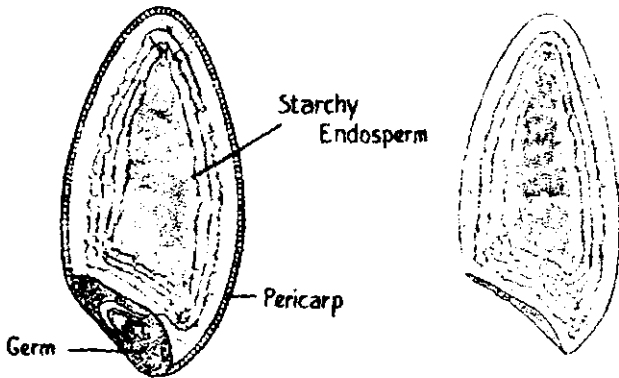
We must now consider various food factors in rice which are influenced in an important degree by milling and parboiling. One of these is *phosphorus*, an essential dietary element and constituent of living tissues. On the average milled rice contains only about half as much phosphorus as home-pounded rice. As a rule, parboiled milled rice is richer in phosphorus than raw milled rice. Actually, however, the amount of phosphorus present in rice of any kind is fairly high and there is no evidence that rice-eaters suffer from phosphorus deficiency.

Rice, in comparison with other cereals and many common foods, is a poor source of *iron*. Machine-milled rice contains less iron than home-pounded rice. Iron is needed by the body for blood formation—it is an essential part of the substance haemoglobin, the red pigment of blood. When destruction and loss of blood corpuscles are taking place, as in such conditions as chronic malaria and ankylostomiasis (hook-worm), iron requirements are increased. Rice-eaters appear to suffer readily from *anæmia* of various kinds when exposed

*In this Bulletin the term "raw" rice means rice which has not been steamed in the husk. It has no reference to domestic cooking.

THE MILLING OF RICE.

When rice is milled it loses the outer layers (the germ and pericarp). These contain more protein, mineral salts and vitamins than the starchy inner parts of the grain (endosperm).



Section of an
UNMILLED GRAIN
Germ and outer layers complete.

Section of a
MILLED GRAIN
Germ and outer layers removed.

**Under-milled rice is more nutritious
than milled rice.**

to malaria or hookworm or when subjected to the strain of pregnancy. Probably the iron content of the poor rice-eater's diet, while sufficient to meet requirements in ordinary circumstances, leaves little margin to allow for the demands imposed by such conditions.

Vitamin B₁ (the anti-beriberi vitamin).—Deficiency of this vitamin produces very serious consequences. The most important difference between highly milled and hand-pounded or under-milled raw rice is in respect of vitamin B₁ content. The loss which takes place on milling raw rice is illustrated by the following figures, which show the vitamin B₁ content of a sample of raw rice at different stages of milling. The figures represent parts of vitamin B₁ per million parts of rice :

Husked only	4.0
Once polished	1.8
Twice polished	1.0
Thrice polished (ready for the market)	0.7

In the case of this sample, milling removed more than 75 per cent. of the vitamin originally present in the husked rice. It has very much the same effect on certain vitamins of the B₂ group, deficiency of which may lead to serious disease.

When rice is previously parboiled, the effect of milling is much less serious. Even "thrice milled" rice will retain as much as 2—2.5 parts per million of vitamin B₁, which is enough to prevent beriberi. We shall illustrate the importance of this fact in a later section by reference to the geographical incidence of beriberi in India. Similarly, the loss of other vitamins on milling is reduced by preliminary parboiling.

Washing and cooking.

Most of the food factors present in rice are little affected by the degree of heat used in cooking. The widely held idea that all vitamins are destroyed when food is heated is quite wrong. But many important dietary constituents are soluble in water and can be washed out of food. Rice is usually washed several times before cooking and may be boiled in excess of water. The extent of the losses in food value which occur depends on the number of washings and whether the cooking water is discarded or not. If rice is washed 3 times and cooked with liberal amounts of water, about 75 per cent. of the iron, and 50 per cent. of the phosphorus, vitamin B₁ and other vitamins of the B₂ group originally present, may be lost. It is the first washing which causes most of the loss. Much more vitamin passes into the wash water than into the water used in cooking.

An interesting practical illustration of the effect of washing on the vitamin B₁ content of rice has been supplied by Dr. B. S. Platt, who until recently was working in Shanghai. The Chinese in South China live largely on milled raw rice and are consequently prone to contract beriberi. Dr. Platt describes the following experiment carried out in groups of factory workers in Shanghai :

"One group of workers was fed on rice freshly and highly milled each day and cooked without preliminary washing. Control groups were observed in rice milled to a similar degree, but washed thoroughly in the ordinary way. Other ingredients in the diet and living conditions were comparable in all the groups. No signs of beriberi developed in the groups on the unwashed rice, whereas in the control groups nearly half the subjects developed signs attributable to vitamin B₁ deficiency."

The digestibility of rice.

A few remarks about the digestibility of rice may be of interest to the reader. Nutrition workers are often told that certain kinds of rice are "indigestible" or cause unpleasant gastric disturbances. People accustomed to highly milled rice, for example, often declare that their stomachs are incapable of digesting any other kind. But the human stomach is a fairly constant organ whatever the social status and dietary habits of its owner. The kinds of rice which are accused by some of being indigestible are usually kinds which are consumed by millions of people without complaint, and there can be no better test of their digestibility. The truth probably is that all ordinary kinds of rice—under-milled, highly-milled, red, white, raw, parboiled, small, large, and so on—can be digested satisfactorily by healthy people, the only exception being freshly harvested raw rice. The human stomach—or rather the human mind—is conservative and resents any change in diet, but within a few weeks both are capable of adapting themselves to a new regime.

(3) *Beri-beri.*

The chief sign of beri-beri is partial or complete paralysis of the limbs, due to degeneration of the nerves, which is often accompanied by dropsy and by weakness of the heart muscle leading to heart failure. Severe beri-beri, unless properly treated, is often a fatal disease. Beri-beri is said to be mentioned in a Chinese medical treatise written as long ago as 3,000 B. C. It is described in a Japanese work to which the date of 808 B. C. has been assigned. Jacobus Bontius, a Dutchman, gave an admirable description of the disease in a book published in Batavia in 1642. In 1837 a young army surgeon in India, Malcolmson, published in Madras "A Practical Essay on the History and Treatment of Beri-beri" which added considerably to knowledge and understanding of the disease.

Beri-beri has thus a long history, and existed before the invention of machine milling. This can be explained by two facts to which attention has already been drawn: it is possible to deprive rice fairly completely of its outer layers by vigorous hand-pounding, and a large proportion of the vitamin can be removed from rice by excessive washing. There is little doubt, however, that the appearance of beri-beri in the East as a widespread epidemic disease in the last half of the nineteenth century was due to the introduction of the rice mill. During the early years of the present century great attention was given to beri-beri in the countries of Eastern Asia, since the disease was a formidable menace to public health, and was extremely prevalent in institutions, labour groups, troops, etc. To-day knowledge of its cause has largely eliminated beri-beri from groups whose diet can be controlled, but in most Eastern countries plenty of cases from among the general population reach the hospitals, and many deaths from this cause still occur.

A number of striking human experiments have been carried out which have clearly demonstrated the connection between beri-beri and highly milled rice. One of these was conducted in 1908 by two workers in the Federated Malay States, Fraser and Stanton. Two parties of labourers were employed in the heart of the jungle on road-making at a distance of 7 miles from each other. One party, consisting of 220, was given white milled raw rice to eat; the other, 273 strong, under-milled parboiled rice. Apart from rice, the diet contained small quantities of salt fish, onions, potatoes and coconuts. Within 6 months, 20 cases of beri-beri occurred in the first group, while the second remained free from the disease. Conditions were now reversed, the first party receiving under-milled rice, the second highly milled. The outbreak of beri-beri in the former abruptly ceased, while cases of beri-beri now appeared in the latter.

We have already referred to the effect of parboiling on the vitamin B₁ content of the rice grain. Over 30 years ago an investigator named Braddon, working in the Federated Malay States, was struck by a curious fact. He observed that Chinese emigrants in Malay suffered severely from beri-beri, while Tamil emigrants from South India escaped. He decided that this must be due to the difference in the kind of rice eaten by the Chinese and the Indians; the former consumed raw milled rice, whereas the latter preferred rice prepared in the common Indian fashion—i.e., parboiled before husking. Starting from the observation, Braddon showed that the same relationships between raw rice, parboiled rice and beri-beri existed throughout the East. His explanation of the beri-beri-preventing properties of parboiled rice was that steaming destroyed some poison in rice.

We now know that it is the vitamin B₁ content of rice which is the all-important factor. Parboiled rice, whether under-milled or highly milled, usually prevents beri-beri because it contains the vitamin in sufficient quantities.

In India the extent of the disease relative to the total number of rice-eaters has always been slight in comparison with that observed in Malaya, Indo-China, Siam, Japan and the Philippines. Although rice is the staple cereal of over half the population of India and beri-beri is known to be a disease associated with ill-balanced rice diets, in most parts of the country typical beri-beri is rare. It is only in the Northern Circars districts of the Madras Presidency that it presents a serious public health problem. In 1935, 35,000 cases of beri-beri were recorded in the Madras Presidency and of these 96 per cent. occurred in the Northern Circars. This peculiar geographical incidence has puzzled various observers. The explanation, however, is simple. An essential difference between the food habits of the people in the beri-beri area and those followed in other rice-eating areas of India is that in the former areas rice is largely consumed in the raw state, as in other Eastern countries outside India. In Bengal, Assam, Bihar, Orissa, and the remainder of the Madras Presidency parboiled rice is usually consumed; this may be home-pounded, but much of it, particularly in Madras, is machine-milled. The superiority of parboiled rice in vitamin B₁ content, shown by laboratory investigations, explains the limited geographical distribution of beri-beri in India.

Other defects of the poor rice-eater's diet.

We have already described the typical diet of the poor rice-eater and pointed out that it is very similar in composition all over India. If the rice consumed is home-pounded or parboiled, intake of vitamin B₁ and certain other food factors will be reasonably adequate, even though the supplementary foods supply these only in small amounts. But, as we have seen, rice, even in the under-milled state, is deficient in other necessary food constituents besides vitamin B₁, and a mere change-over from milled to under-milled rice, which materially increases vitamin B₁ intake, will not make typical rice diets into really "well-balanced" and satisfactory diets. This end can only be achieved by the inclusion in the diet of certain kinds of supplementary foods in sufficient quantities.

What are the best supplements? This question has been studied in a variety of ways. For example, it has been found that when children on a poor rice diet receive milk regularly there is an immediate increase in the growth rate and improvement in health. Table 5 shows the result of an experiment in which a group of very poor boys in Madras city was given milk for 3 months, while another group, precisely similar in age and other respects, received none.

TABLE 5.

The effect of giving extra milk to poor children in Madras.

	Group receiving milk.	Group receiving no milk.
Number of children	20	19
Average gain in weight (lb.)	1.9	0.8
Average gain in height (inches)	0.66	0.36

The milk-fed children put on more than double the weight of the other group and gained nearly twice as much in height; at the end of the experiment they were more lively and looked more healthy than the boys who received no milk. Milk is perhaps the best supplement to rice diets. Whole milk contains good protein, calcium, vitamin A and various vitamins belonging to the B₂ group. Skimmed milk, which contains all the important factors present in whole milk except vitamin A and fat, is also of striking value as a supplement. Much of the good effect of milk is due to the calcium it contains; it is a rich source of this element.

The results of a great many observations and experiments can be summarised as follows: The poor rice-eater's diet, even when home-pounded or parboiled rice is consumed, is deficient in proteins of animal origin, vitamins A and C, the B₂ group, calcium and iron. This means, in practice, that his intake of such foods as milk, pulses, vegetables, fruit, meat, eggs, etc., needs to be increased to "balance" the preponderance of rice in the diet. We shall discuss means of supplementing rice diets in greater detail in a later section.

(4) *The improvement of the rice-eater's diet.*

We have been considering some of the defects of rice diets as consumed in India. We must now face the question—how can these be improved? First of all, let us consider methods of improving the staple itself.

(a) Rice remains a foodstuff which is deficient in certain important constituents whatever the botanical variety or method of cultivation. It is unlikely that centuries of agricultural research could succeed in producing a rice which would be a rich source of calcium and vitamin A in relation to human requirements. There are, of course, slight differences in the composition of different varieties, but these are of no great importance. It follows that we must not expect the "rice problem" to be solved and the defects of the poor rice-eater's diet made good, by the discovery or development of exceptionally nutritious varieties of rice.

Agricultural research workers and departments have already accomplished much by the introduction and popularisation of high yielding strains (See Table 3). Let us hope that in the future these most valuable activities will be further extended. On these points we may quote from Sir John Russell's report on agriculture in India.*

"In dealing with food crops intended for home consumption the agriculturist should aim at securing the largest and healthiest crops possible, but he need not concern himself with trying to change their composition. The amount of alteration possible is too small to justify the expenditure of time and resources that can better be spent in other ways."

*"Report on the work of the Imperial Council of Agricultural Research in applying science to crop production in India." 1937. Manager of Publications, Delhi: Price Rs. 1-14-0 or 3s. 3d.

“Investigations should be directed to increasing the output per acre of food crops with a view to ensuring full supplies and liberating land for the growth of supplementary crops and of fodder crops for the production of milk..... The really vital matter is the food value per acre not per ton of produce.”

The content of rice in vitamin B₁ and other important food factors is greatly affected by milling, washing and cooking. The easiest way of raising the nutritive value of rice as consumed is by minimising the losses brought about by these processes.

(b) *Parboiling*.—We have already discussed the effect of parboiling. The fact that parboiled rice, even when highly milled, retains certain vitamins in fairly abundant quantities, whereas raw milled rice does not, should be more generally realised. It has great importance in India. The rice problem in India differs from the rice problem in such countries as Java, Siam and China because in India the majority of rice-eaters consume parboiled rice. It is very desirable that they should continue to do so, and any tendency to abandon parboiled rice in favour of raw rice should be checked by suitable education and propaganda.

In South India raw rice is usually preferred by the Brahmin community. The classes which ordinarily consume parboiled rice often use raw rice on religious and other festivals. Raw rice is sometimes considered more “civilised” than parboiled, and because of this families which have risen in the world may change over from the latter to the former. But taking the country as a whole there does not seem to be any general tendency to replace parboiled by raw rice. It is noteworthy that labourers from South India who have emigrated to Malaya usually continue to consume parboiled rice though living among people who take only raw.

Rice just harvested can be immediately consumed if the paddy is parboiled whereas unboiled paddy (rice in husk) must be kept for a few months before consumption. This fact gives parboiled rice some advantage when stocks are short.

(c) *Milling*.—The question of milling must now be considered. Here the distinction between raw and parboiled rice must be borne in mind. The milling of raw rice very seriously reduces the nutritive value of the grain. In the North-East parts of the Madras Presidency there are perhaps some 10 millions of people who consume raw rice, and in such areas the milling problem assumes particular importance. But even with parboiled rice there is some lowering of value on milling, and under-milled parboiled rice is preferable to highly milled parboiled rice from the standpoint of nutrition.

In many Eastern countries the use of machine-milled rice has become almost universal and the practice of preparing rice for consumption by domestic methods such as hand-pounding has disappeared or is disappearing. An investigation to throw light on the causes underlying this change has recently been carried out by the Nutrition Research Laboratories, Coonoor, in the Madras Presidency, where the habit of consuming machine-milled rice is more widely established than in most other parts of India. Information was sought and obtained from many individuals, including members of the legislature, lawyers, doctors, public health and agricultural officers, teachers, welfare workers, etc., most of whom were in close touch with the people in the towns and villages, and had intimate knowledge of their living conditions

and economic difficulties. By this means, supplemented by other methods of investigation, it was possible to obtain a picture of the situation as it exists in South India. The main conclusions drawn from the results of the enquiry are summarised in the passages which follow.

The extent of the change.—The habit of using machine-milled rice is spreading in both rural and urban areas. It is only in a few remote rural areas that the consumption of home-pounded rice remains the general custom. Taking all the available data into consideration, we may estimate that in 1939 about 70 per cent. of the rice-eating population of the Madras Presidency consumed machine-milled rice. The decline in the use of home-pounded rice affects all communities.

In South India the substitution of milled for home-pounded rice has thus proceeded far, and organisations and individuals attempting to encourage the use of the latter must face this fact. It is not a question of checking a process in its early stages, but of changing a habit which is widely established and appears to be extending year by year.

The spread of rice mills.—The means and motives responsible for the change must now be discussed. The fact that 70 per cent. of rice-eaters in Madras now eat machine-milled rice must mean that there has been a great increase in the number of rice-mills during the last 40 years. Large rice mills, including establishments dealing with groundnut, oils, and other products in addition to rice, are registered under the Indian Factories Act as "Large Industrial Establishments". The number of these does not appear to have grown within the last 8 years, as the following figures indicate :

Year.	Number of mills registered under the Factories Act (Madras Presidency.)
1931	559
1932	538
1933	566
1934	583
1935	530
1936	551
1937	554

In the early years of the century there was, however, a great increase in the number of mills classed as factories. We have been informed that in 1900 there was only one of these. By 1912 the number had risen to 68, and in 1917 and 1922 there were 140 and 278 respectively.

The total number of large and small rice mills in the Madras Presidency in 1936 was about 3,500, so that those coming under the Factories Act do not form a large proportion of the total. It is the small mill, often worked by a group of not more than 5 individuals, which within recent years has spread far and wide, even in remote country places. Such mills can be found in villages with a population of 2,000 or less. The usual type of machine employed in the small mills is the "Engleberg huller and polisher", originally an American production, which has been copied and modified in Indian foundries.

The extended use of the rice mill is bound up with other changes in the life of the people. The development of transport and the improvement of roads enables the paddy grower to bring his grain to the mill. The motor bus, rattling everywhere about the countryside, has loosened the bonds which attach the villager to his own plot of ground and traditional manner of life. Cheap electric power is obtainable over wide areas, and other sources of power—the steam and internal combustion engine—are familiar and obtainable. All these factors have played a part in the abandonment of the ancient practice of hand-pounding.

The saving of labour.—The popularity of the rice mill is often attributed to “laziness” or “love of ease” on the part of the villager. This raises the question—is home-pounding hard work? To pound about 2½ lbs. of paddy, between three and four hundred strokes of the pounder, which weighs 6 pounds or thereabouts, are required. Ten minutes pounding will produce, from this quantity of paddy, about 1½ lbs. of rice ready for consumption. Allowing for the time occupied in winnowing, etc., we may reckon that two women can in one hour pound enough rice for the daily requirements of an average family.

If each rice-eater pounded his own rice daily, the task would take him less than 10 minutes. The average villager has plenty of leisure for the task; it is not unlikely that the time which village women used to spend in pounding rice is now spent doing nothing. But the alternative—to take the paddy to the mill which can carry out the equivalent of several hours' hand labour in a few minutes—may involve no effort at all. In certain areas the mill owners collect the paddy in their own carts and mill it for a small charge. A frequent arrangement is that the paddy is milled for nothing on the condition that the miller keeps the bran. Such a transaction appeals to the villager, who is nevertheless depriving himself of fuel (the husk) and food elements of high nutritive value contained in the germ and pericarp.

Machinery was invented by man to save himself labour. In this instance, however, the amount of labour saved is not very large, and the mill cannot be regarded as absolutely necessary for maintaining the food supply of the people. It is possible, however, that many village women, exhausted by malnutrition, ill-health, and continuous child-bearing, instinctively avoid undertaking extra work demanding any physical effort. To such people the coming of the mill must seem to be a blessing.

Various obstacles to the practice of home-pounding.—Families employed in daily labour in return for wages have less time and energy to spare for household duties than independent or semi-independent cultivators. In the former group are included industrial and plantation labourers and landless villagers. Women are employed as daily labourers as frequently as men.

Under present conditions it may be difficult for the wage-earner or small landholder, however anxious he is to live on home-pounded rice as a staple, to obtain paddy to pound. Various obstacles and difficulties were well described by Dr. B. Pattabhi Sitaramayya in an interesting note sent to the Nutrition Research Laboratories, Coonoor. Part of his report, which refers in particular to the Godavari and Kistna deltas, may be quoted in full:

“Home-pounded rice means home storage of paddy. Most of the small land-holders own not more than two or three acres. They are in debt. What little paddy they grow is sold out in a lump perhaps at the very field itself, in order to meet the liabilities of debt, or some expenditure incurred by social ceremonies, or the purchase of cattle, construction of houses, and so on. In the months of January and February (harvest time) capital expenditure

awaits the landholder, which has to be met immediately and can only be met by the sale of paddy For the time being the house-holder is able to meet capital expenditure by selling his paddy and live on credit till the beginning of the next year when again the sale of paddy will enable him to meet existing and future liabilities. In effect then the villager has no paddy to pound."

The paddy which the small rice-grower produces may thus become an article of commerce and not be retained as food for his own use. With the money obtained from the sale he buys machine-milled rice which may originate in another part of the Province or be imported from Burma or Siam. It is difficult to estimate the proportion of small cultivators forced to dispose of their grain for the above reasons; it appears, however, that the practice described is common throughout the province.

Dr. Sitaramayya goes on to note other factors which operate against the practice of home-pounding by small-holders, agricultural labourers and industrial workers :

"There is no place to store the paddy. There is no capital to purchase paddy or a bazaar where it can be purchased in small quantities. You can go to the bazaar and buy a few pounds of rice. It is very difficult to buy a few pounds of paddy because paddy is sold in large quantities at a time; there is no market where you can purchase your day's needs."

"Moreover, to pound paddy you require three or four instruments: a couple of pounders each costing about Rs. 1-4-0, a sieve costing about 4 annas and a stone with a hole in it planted in the ground For home-pounding the height of the house should be 8 feet clear—5 feet for the persons standing, and 3 feet for the pounders to be raised. Most people live in huts or small places, and several families are huddled together. Want of home accommodation is a real obstacle in the way of pounding—home-pounding implies spacious accommodation, and room for storing the paddy. All these are unobtainable by the ordinary wage labourer."

In certain parts of the Presidency it appears that the villagers no longer possess the necessary instruments for pounding. Sometimes the pounders are burnt because it is felt that there is no further use for them.

The above passages suggest that, in some areas at any rate, economic and living conditions would make the revival on a large scale of the practice of hand-pounding by poor families very difficult. This is especially so in the case of industrial workers in towns and cities.

When agricultural labourers are given paddy in small quantities in lieu of wages they may pound the paddy in their homes. The practice of paying wages in this manner does not, however, appear to be very common in the Presidency as a whole.

Home-pounded rice as an article of commerce.—The next point for consideration is the possibility of home-pounded rice becoming a staple article of commerce, widely sold and consumed. The cost both of home-pounding and machine-milling naturally varies from place to place. The following figures, based on information obtained in various parts of the Presidency, give a rough idea of the cost involved :

	Rs.	A.	P.
Average cost of machine-milling 100 lbs. of paddy	0	2	6
Average cost of hand-pounding 100 lbs. of paddy	0	5	6

In general the price of the labour necessary to pound a given quantity of paddy is double that demanded by a miller for machine-milling a similar quantity. Let us suppose that on the average 100 lbs. of paddy yields 65 lbs. of rice. If the paddy is home-pounded the weight of the yield is greater than when the same paddy is machine-milled to a high degree, but the difference is small. On the above reckoning, the labour charges involved in producing 100 lbs. of hand-pounded rice will be 4-5 annas greater than the cost of producing a similar quantity of the machine-milled product.

The cost of labour is naturally reflected in the price of the two kinds of rice. One hundred pounds of home-pounded rice usually cost 5-8 annas more than 100 pounds of machine-milled rice. The monthly requirement of an adult man consuming rice as his staple food may be estimated as about 40 lbs. The cost of this quantity of average milled rice, at current retail prices in the Madras Presidency, is Rs. 2-11-0 or thereabouts*. The consumption of home-pounded rice in the place of machine-milled rice will increase monthly expenditure on rice by about 3 annas. For an average family containing 4 or 5 members, the extra cost would be about 12 annas per month. This is no small sum in relation to the earnings and income of the poorer classes in India. Even the smallest difference in price is all-important to the poor. Machine-milled rice of inferior commercial quality, including various varieties of "broken" rice imported from abroad, may cost 20-30 per cent. less than local rice of good quality. Under present conditions home-pounded rice, if put on the market in large quantities, would have to meet the competition of the cheaper varieties, which tend to be consumed by the poorer classes. It is among these classes that the state of milling of the staple cereal assumes the greatest importance.

In certain areas there used to be groups which earned their living, partially or wholly, by pounding rice for their neighbours. Such labourers now often prefer to do other kinds of work (on plantations, industrial undertakings, etc.), which in general are better paid than pounding. The opportunities for obtaining such work have increased within recent years, particularly in urban areas and villages surrounding industrial centres.

The value of by-products.—In the small mills, husking and polishing are carried out in one process, and the millings consist of a mixture of husk and bran. The fuel value of this mixed by-product is low and it is often thrown away, the demand being small. It is also of very low value as cattle food, though sometimes used for this purpose. Veterinary officers have found that a mixture of husk and bran may cause serious digestive disturbances in cattle, as indeed is to be expected from the nature of the husk. In the big mills, husk and bran are separately removed. Unmixed husk makes suitable fuel for steam engines in mills. The pure bran obtained in the big mills is valuable cattle food and commands a good price.

In villages in which the practice of pounding persists, the husk is often used as fuel and any bran removed on pounding may be used to make cakes for human consumption or as cattle food. The loss of these by-products must be considered one of the disadvantages involved by the spread of rice mills.

The attraction of highly milled rice.—The well-to-do in South India usually prefer their rice white and well-polished, because they find such rice more pleasing to the eye and more palatable than coarser varieties. Some people think that one of the most important reasons why the poor have taken to milled

*This was written before the outbreak of the war. Subsequently prices have risen.

rice is because it is consumed by their wealthier neighbours ; in a word, *fashionable*. Undoubtedly this has played some part in creating the present situation. But economic causes, such as those considered in the preceding section, are of much greater significance. If the educated classes began to consume under-milled rice, this might have some influence in the habit of the poor, but the underlying economic factors would remain unchanged.

In this connection we may refer to the unfortunate attitude often adopted in South India towards the millets, particularly ragi. The millets are somewhat superior in nutritive value to rice and it is a good thing for the rice-eater to take some millet as part of his daily food. But if ragi is introduced into the diet of, let us say, a girls' boarding school, in place of an equivalent quantity of rice, there is often the greatest difficulty in persuading the girls to eat it, even when ragi is the staple food of the district to which they belong. There is a social prejudice against ragi in South India ; it is often regarded as food suitable only for poor and ignorant villagers—also as the food of prisoners in gaols. Adolescent country boys and girls in institutions, who are perhaps hoping to raise themselves above the status of their parents, feel entitled to eat the cereal of the townsmen and the educated classes—milled rice. The same prejudice affects the population generally and operates, though to a somewhat smaller extent, in the case of the other common millets.

Storage and preservation.—Paddy can be stored in properly constructed granaries for more than a year without deterioration. Highly milled rice, stored in suitable receptacles and kept free from weevils, will remain in good condition for a year or more. Husked rice—*i.e.*, rice from which the husk has been removed leaving germ and pericarp intact—usually becomes rancid within two or three months or less because of its relatively high fat content ; such husked rice, however, never appears on the market as an article of commerce.

In ordinary home-pounding rice loses most of its germ and nearly half its pericarp. Home-pounded rice may keep in good condition for several months but its keeping qualities are inferior to those of highly milled rice. Similarly, if the mills were to turn out under-milled rice, this would also deteriorate more rapidly than highly milled rice. Possibly under-milled parboiled rice would have better keeping qualities than under-milled raw rice.

It is sometimes suggested that the inferior keeping qualities of under-milled or home-pounded rice would tend to make such rice dearer than highly-milled rice. It appears, however, that, in South India at any rate, the effects of storage are of minor importance as far as the internal production and consumption of rice are concerned, and that they would have little influence on price levels if under-milled rice became an article of commerce. Under ordinary circumstances, rice, with or without its husk, is not stored for more than a few months. The Province lives, as it were, from hand to mouth as regards its food supply. Stocks of home-grown and imported rice are rapidly exhausted and replaced by the next crop or by fresh imports. Elsewhere in the East the situation may be different. When circumstances demand more prolonged storage, the keeping qualities of rice must be of great importance ; this will apply to rice as an article of international trade. It is expensive to transport rice as paddy and the large exporting countries prefer to ship their rice in the highly-milled state, thus avoiding the risks of premature deterioration.

The situation elsewhere in India.—The change-over from pounded to machine-milled rice has proceeded further in Madras than in most of the other rice-consuming parts of the country. In Bengal, Assam, Bihar, Orissa, the

United Provinces and Hyderabad, the greater part of the rice-eating population still consumes hand-pounded rice. In Burma, on the other hand, the change has proceeded further than in Madras, probably because Burma has a large export trade in milled rice. The following estimates were supplied by Marketing Officers and others :

	Percentage of the rice-eating population using home- pounded rice.
Assam	85
Bengal	75
Bihar	90
Hyderabad	70
Orissa	80
Travancore	45
United Provinces	85
Burma	20
Madras	30

These figures can be regarded only as rough approximations. They nevertheless convey an idea of the present position.

Even in Provinces and States in which it is still the general habit to eat home-pounded rice, the factors which have furthered the spread of mills in Madras are operative ; it is quite conceivable that in 20 years time the practice may be as rare in Bengal and elsewhere in India as in Madras. It is therefore important to decide what attitude should now be adopted towards the penetration of the mill into areas in which domestic methods of preparing rice for consumption are still followed by the majority of the population.

Practical steps.—We have been considering the *reasons* why people eat machine-milled rice instead of home-pounded rice. The next question is what should be done about it.

In such areas as the Madras Presidency, where 70 per cent. of the population consumes machine-milled rice, the task of bringing about a general revival of the practice of home-pounding would be enormous. The people have learned to regard the mill as a convenience and it has become interwoven into the economic life of the country. In the circumstances drastic legislation to prevent the further construction of mills, or to do away with existing mills, would not be practical politics.

In areas into which the mill has not yet penetrated, and in which the people still prepare rice for consumption by hand as a matter of course, the position is different. Here the case for checking the spread of mills by legislation appears to be stronger. But in nearly all the areas outside the Madras Presidency in which the practice of home-pounding persists, parboiled rice is eaten. As has been said, there is some difference in food value between home-pounded and machine-milled parboiled rice, but the difference is not very great. It is not great enough to justify expensive and probably very unpopular legislative and administrative action against the mill.

What can and should be done throughout India is to educate people about the food value of rice in its various forms. In this way a demand can be created for rice with its outer layers partially intact. This demand can be fulfilled either by hand-pounded rice or by under-milled (once-polished) rice

produced by the mills themselves. There is nothing to prevent the mills turning out such a product if there is market for it. With regard to hand-pounding, we must remember that its encouragement will create employment of the "cottage-industry" type, which is one of the aims of rural reconstruction organisations in India.

In this connection we may draw attention to a wooden "hand-huller", the use of which is being advocated by various agencies. This consists of two grooved wooden drums in contact with each other, the upper drum being rotated by hand. Paddy placed between the drums is shelled, but the outer layers of the grain are not removed, so that the resulting rice is of high nutritive value. The hand-huller costs only a few rupees.

Mention may also be made of another apparatus for husking paddy without removing the outer layers. This is a Japanese invention and may be called the "Japanese huller". It is worked either by hand or electric power. In this machine husking is achieved by the grain falling in a stream on a rapidly rotating roller covered with hard rubber. The paddy is thrown against a stationary rubber surface about one inch distant from the rotating roller and as a result the husk is split. As the husk and rice fall together, a fan operated by the same levers blows off the husk. Rice husked by the wooden grinder and the "Japanese huller" is identical in appearance. A machine based on the principle of the "Japanese huller" could readily be manufactured in India; the cost would probably be Rs. 75—100. It is much less laborious to produce large quantities of husked rice by the use of the Japanese huller than by that of the wooden grinder. The former would therefore be suitable for institutions in which the consumption of rice is considerable.

Highly milled *raw* rice is a danger to public health. If legislative action is to be taken, it should be directed against this kind of rice. This might take the form of prohibiting altogether the milling of raw rice beyond a certain degree, which can be defined by nutrition workers. It would correspond roughly to the "once-polished" rice which is produced in the preliminary stages of milling in a big modern mill. Any samples of raw rice suspected of being milled beyond the permissible degree would be liable to seizure and the proof of their being illegal would then depend on tests in a Government laboratory.

There would be no restriction on the milling of parboiled rice. This might have the effect of popularising this kind of rice in the areas in which beri-beri is a serious problem. In certain of these areas parboiled milled rice is eaten for a few months after the harvest, because parboiling makes freshly-harvested rice immediately fit for consumption. If the habit of eating parboiled rice were followed all the year, beri-beri would disappear.

Institutions.—Only hand-pounded rice, or under-milled rice produced by the mills, should be used in all Government institutions. This recommendation applies equally to raw and parboiled rice and may be extended to include all private residential hostels. The Government of Madras has made the use of hand-pounded rice compulsory in gaols and hospitals, with the dual object of improving the diet and creating employment. In the gaols the rice is pounded by the prisoners themselves.

(d) *Washing and cooking.*—Dr. Platt has advocated the use of unwashed rice for the prevention of vitamin B₁ deficiency. He makes the following recommendations :

“Washing of rice before cooking may drastically reduce the beri-beri preventing factor; this is true for rice of all grades of milling. The need for washing can be eliminated:—

- (i) If polishing powders are abolished—they appear to serve no useful purpose, and must be washed off as they may be definitely harmful if eaten;
- (ii) if the storage is so good that the grain does not develop an undesirable flavour. Storage of de-husked grain in hermetically sealed containers meets this requirement;
- (iii) if milling is carried out shortly before the rice is required for consumption—milling is itself a cleansing process, and if the product is subsequently handled hygienically, further cleaning would be superfluous.”

It is the first washing which removes most of the vitamins and other nutritive elements. Subsequent washings have a much smaller effect. There is thus not much to be gained by reducing the number of washings. Washing is required unless rice is very clean and of good commercial quality. Improvement in the cleanliness of mills, and bazaars and shops where rice is exposed for sale, would reduce the necessity for vigorous and repeated washing.

In cooking the least possible amount of water should be used and the cooking water should not be thrown away.

The education of the people about such questions is necessary. Everybody should have a clear idea of what happens during the milling, washing and cooking of the most important food in the country.

(c) *Supplements.*—The kind of diets which are actually consumed by rice-eaters has been shown in Table 4. Let us compare the rice-eater's diet with a “well-balanced” diet which is based on rice but contains plenty of other foodstuffs as well. This is done in Table 6. The “actual” diet is an average one based on the results of surveys in many parts of India. The “well-balanced” diet closely resembles various diets which have been recommended by the Nutrition Research Laboratories, Coonoor.

TABLE 6.

The “actual” diet of the rice-eater and a “well-balanced” diet.

(Ozs. per adult man daily.)

Food.	“Actual” diet.	“Well-balanced” diet
Rice	15—25	15
Pulses	0.5—1.5	3
Milk	None or negligible amounts.	8
Leafy vegetables	0.5—1.0	4
Non-leafy vegetables	2.0—5.0	6
Fruit	negligible	2
Vegetable fats and oils	less than 1.0	2
Fish, meat and eggs	0.5—1.5	3 (when milk is absent from the diet or taken in negligible quantities.)

(with condiments and spices in small quantities.)

This at once gives us an idea of what to aim at in order to improve the poor rice-eater's diet. Let us discuss the question of supplements in greater detail.

(i) The various millets and whole wheat have a higher food value than milled rice. It is therefore a good thing that some wheat or millet (say 4 to 6 ozs. daily) should be included in rice diets. The cultivation of wheat is limited by climatic conditions, but the millets are grown all over the country. Agricultural workers should give special attention to increasing the yields and extending the cultivation of these cereals. Unfortunately the millets (ragi or marua; cambu or bajra; cholam, Italian millet, etc.), are often considered to be an inferior type of food. Nutrition research has shown that this idea is false.

(ii) *Pulses*.—Most rice diets contain too little pulse. Pulses supply some of the vitamins and other essential dietary constituents in which rice is deficient. Since they are rich in the anti-beri-beri vitamin, they are particularly valuable as a supplement when the diet is based largely on raw milled rice. Agricultural departments should aim at increasing the cultivation of pulses by developing improved varieties, etc.

(iii) *Milk*.—In many parts of the country the poor rice-eater consumes no milk at all. We have already remarked that milk is the best supplement to rice diets. It follows that every effort should be made to increase the production of milk and milk products.

When whole milk is not available because it is too expensive or produced in insufficient quantities, milk reconstituted from skimmed milk powder can be recommended. This applies especially to children's homes. Butter-milk, unless excessively diluted, is a valuable addition to the poor rice-eater's diet.

Typical rice diets are deficient in calcium. This deficiency can be made good by milk. Other foods rich in calcium include ragi and leafy vegetables. Calcium can also be provided in the form of a calcium salt—*e.g.* calcium lactate. About one gramme of calcium lactate daily definitely improves the state of nutrition of children on a rice staple. The cost of this is only 1-2 annas per child per month.* Calcium lactate may be given regularly to school children as a *partial* milk substitute, and it may be strongly recommended for pregnant and nursing women.

(iv) *Vegetables*.—Leafy vegetables, which are rich in pro-vitamin A and calcium, are particularly valuable supplements to poor rice diets. Surveys have shown that intake is everywhere below the desirable level. The non-leafy vegetables are usually eaten in greater quantities, but the amount recommended in the well-balanced diet is seldom reached. A greater consumption of vegetables of any kind would improve standards of nutrition in India. On this point the Russell Report may be quoted :

“Much more work should be done on the cultivation of green leafy vegetables and demonstration fruit and vegetable gardens should be set up adjacent to the villages where they can receive manure and water. A marked extension of vegetable growing is very desirable.”

We may lay special emphasis on the development of kitchen gardens in villages. This has been strongly recommended by the Nutrition Research Laboratories and is now part of the programme of Health Units, etc., working among village populations. In some places considerable success has been achieved. Normally the villager in many parts of India is not interested in

*At the pre-war price.

growing vegetables even when land and water for this purpose are available. Education and propaganda are required to teach him the value of vegetables as food and to persuade him to grow these for his own use when circumstances permit. More attention might be given to vegetable growing by agricultural research workers and departments.

(v) *Fruits*.—Not enough fruit is grown and eaten in India. Fruits are rich in various vitamins, particularly vitamin C, which prevents scurvy. The Indian gooseberry (Amla) is particularly rich in Vitamin C. Certain fruits are a good source of vitamin A. Mangoes, papayya, tomatoes and oranges are among the fruits which are of high nutritive value. Emphasis may be placed on the tomato, a cheap food of high nutritive quality which is being successfully popularised in certain parts of India.

(vi) *Vegetable oils and fats*.—The rice-eater's diet is normally very poor in fat and his intake is below the standards of fat intake usually recommended. His intake of vegetable fats and oils could with advantage be raised. An increased production of oil seeds by selective and other methods is therefore to be desired.

(vii) *Eggs, fish and meat*.—Eggs are of high nutritive value, and an increase in production is to be recommended.

Meat, which in some respects makes a good supplement to rice diets, is eaten only in very small quantities or not at all in most parts of India. In the existing economic circumstances a material increase in supply is not very feasible.

Fish is a food of considerable value. Fish muscle can supply various important food factors, and small fish, when eaten whole, are particularly valuable because they are rich in calcium. The fishing industry in India is in a very backward condition and a large potential source of good food remains untapped. The yield is a mere fraction of what it might be if efficient methods such as those followed in Europe and Japan were applied. The industry is handicapped by being almost wholly in the hands of poverty-stricken fishermen who are unable because of ignorance and lack of capital to take advantage of new and improved methods. Problems of transport, refrigeration, marketing, etc., require a great deal of investigation. It is a pity that at present so little attention should be paid to the development of fisheries because a greater intake of fish would unquestionably do something to improve standards of nutrition in India.

Cod liver oil, imported from Norway or Newfoundland, is widely used in India. Being rich in vitamin A, it is of great value for malnourished children. Cod liver oil is not costly, but its distribution by dispensaries, mission hospitals, etc., to people in need of it has often to be limited because of expense. It would not be an exaggeration to say that the majority of Indian children could be improved in health by the regular administration of cod liver oil. A liver rich in vitamin A is not a monopoly of the cod. There are fish available in Indian waters which might supply abundant liver oil of high vitamin potency; the liver oils of certain of these have, in fact, many times the potency of cod liver oil. The development of industries for the production of edible fish liver oil in India might be of considerable value both commercially and in the improvement of public health.

The cost of cod liver oil is bound to increase as the result of the war. There may in fact be a serious shortage. In the circumstances the question of substitutes is of great importance. Mention may be made of one substance which is rich in pro-vitamin A. This is red palm oil, obtained from the fruit

of the tree *Elaeis guineensis*, which is grown extensively in West Africa and Malaya and has been introduced on an experimental scale into tropical India. Red palm oil has already been successfully used as a substitute for cod liver oil in hospitals and dispensaries.

(viii) *Sugar*.—In India sugar has been manufactured from cane for many centuries. The sugar cane originated in the Ganges valley, and it is said that about the year 648 A. D. the Chinese Government sent officials to India to study its cultivation and methods of extracting the juice. During the last few years the sugar industry has shown remarkable development in its original home as the result of protection and applied science. The problems of increasing the sugar cane crop, and improving methods of utilisation and manufacture, have been attacked along scientific lines. But in spite of the increase in production, the *per capita* consumption of sugar in India remains small in comparison with consumption in Europe and North America.

An increase in the supply of sugar in India is all to the good ; any increase in total food production is desirable. But sugar, whether refined or unrefined, is a food of limited value. While it is a concentrated source of food energy, it contains no protein or vitamins. An increased intake of sugar will not help to "balance" the poor rice-eater's diet. Other changes and improvements which have been described in the Bulletin will achieve this purpose more effectively.

OUR FOOD LUCKNOW CITY



By S. K. RUDRA, M.A. (CANTAB.)—1944

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PREFACE

THIS paper on " Our Food " is one of a series of lectures entitled " Our City, arranged by the Lucknow Social Service League. Mr. John Barnabas, the indefatigable and enthusiastic Secretary, approached me and desired that I should read a paper on this subject. I suggested that Mr. R. F. Mudie, then Chief Secretary to this Government, should be approached instead of me for this purpose. To all who know it is no news that, it was Mr. Mudie, who was the principal brain and the restless driving energy behind all schemes of food supplies in this Government. He played the predominant part in the programme of arrangements of procurement and distribution of foodgrains in the Province. He was responsible for this till he left the Province to assume the office of the Governor of Bihar in September, 1943. Since he left, the heavy responsibility of this part of the administration has been shouldered by Sir William Ibbotson, Adviser to Governor, Supplies. It need hardly be mentioned, however, that Mr. Mudie always had the sage advice and constant guidance of His Excellency Sir Maurice Garnier Hallett to fall back upon. Time and again he approached His Excellency for guidance in respect to the various plans and schemes he prepared. The decisions in all major matters were of Sir Maurice Hallett himself. There could have been no fitter person to deliver this lecture to the citizens of Lucknow than Mr. Mudie. He was, however, too busy, and passed on the task to me.

Dr. Radha Kamal Mukerji, Professor of Economics at the University of Lucknow, did me the honour to preside at this meeting held in the Municipal Town Hall on November 26, 1943. The paper, to my surprise, was on the whole well received. Sir Maurice was kind enough to read it, subsequently. He was good enough to suggest that it might be published. I am grateful to him for his appreciation. His Excellency has been, consistently, most sympathetic to various economic problems which it has been my privilege to present to him from time to time. The paper is thus being published. It is hardly necessary for me to indicate that the views expressed are my personal opinions. In no way do they commit Government.

The matter of the paper has been brought up to date, since much time has elapsed when it was first read.

In the body of my paper I offered a suggestion that the local Colleges, and the University, should take up the study of food-supply and allied problems with greater intensity. They would thus render valuable service in the collection of statistics and other economic data which is woefully lacking in respect to food-supply problems in our various cities. For instance, the question of adequate nutrition of the various sections of the population, the young and adolescent, of the poor and middle classes in particular, is matter of vital importance. Not only urban, but also certain categories of the rural population, deserve attention. My suggestion is obviously extended to my own University of Allahabad, and to other sister Universities in the Province.

I would like to acknowledge my indebtedness, which is much, to Mr. K. C. Jain, M.A., of the Economics and Statistics Department. He has

laboured heavily on my behalf. All figure and statistical work has been his. But for his willing aid, this paper could not have been written. I would also wish to acknowledge the help received from Mr. Fateh Bahadur Nigam, M.A., Economic Intelligence Inspector, Lucknow (now Senior Economic Intelligence Inspector, Meerut Region), in respect to municipal statistics of food supplies coming into Lucknow City. The note in Appendix III on the supply of Fruits, Eggs, Poultry, Fishes and Meat, has been kindly prepared by Mr. John A. Manawwar, Provincial Marketing Officer. I gratefully acknowledge his help. Mr. A. D. Pandit, I.C.S., Deputy Secretary to Government in the Civil Supplies Department, was kind enough to furnish me with a Note on Salt. Appendix IV. Scarcity of salt is, happily, now a nightmare of the past! To Mr. Pandit I offer my thanks for this and for other help so readily given, when he and I worked together in the erstwhile Department of Price Control. I also wish to acknowledge the help, ungrudgingly given, by the Civil Supplies and the Rationing Departments of the Government. To Mr. L. P. Hancox, O.B.E., I.C.S., Secretary, Civil Supplies and Mr. E. A. Midgley, I.C.S., Deputy Secretary, Rationing Department I particularly offer my thanks.

LUCKNOW :
September 11, 1944.

S. K. RUDRA.

particularized to certain Research Laboratories only. Naturally, therefore, our agriculture, which is nearly the exclusive source of our food supplies, was not fostered from the point of view of serving the basic needs of the people, namely their dietics. We depend surprisingly little on marine products to furnish our food requirements, unlike island countries. Except for rice, which was imported mainly from Burma to the extent of about 2 million tons annually, India as a whole obtained comparatively little in the matter of food from foreign lands.* Drugs, drinks and medicines have been excluded from our consideration. The position of India's food supply consequently is mostly a variable of internal factors, operating upon our agriculture.

* The following table will show that the effect of India's imports and exports of grains, flour and pulses on her food economy has been a net addition to the internal supply to the extent of the corresponding purchasing powers varying from 2 annas 6 pies per head per annum (in 1938-39) to 6 annas 11 pies per head per annum (in 1939-40) during the period 1938-39 to 1940-41. Figures for subsequent years are confidential. Taking these figures as indicative of quantities in the absence of further requisite data in regard to the purchasing power of the rupee, it can be safely said that India's dependence for her food on foreign countries is not very prominent.

TABLE NO. I.—Effect of the imports and exports of grains, flour and pulses from India on the food position of the country (1938-39 to 1940-41)¹

Years	Total imports	Total exports	Net imports	Population of India	Effect of (4) per head per annum on the food economy of the country
1	2	3	4	5	6
	Rs.	Rs.	Rs.		As. p.
April 1938—March 1939	1,37,646,473	78,053,542	59,592,931	378,822,195	+ 2 6
1939-40	2,18,054,101	51,397,783	1,66,656,318	383,910,075	+ 6 11
1940-41	1,43,485,286	60,279,495	83,205,791	388,997,955	+ 3 5

¹N.B.—(1) Figures for imports and exports have been taken from the "Accounts relating to the sea-borne Trade and Navigation of British India."

(2) Figures for population of India have been interpolated for 1938-39 and 1939-40 on the basis of the census figures for 1931 and for 1941.

(3) Since a suitable index number is not available for grains, flour and pulses, no adjustment of the effect in column 6 is possible in terms of the purchasing-power of the rupee with reference to time or to the imports and the exports.

Apart from his customary practice of sowing for the family sufficient crops, the peasant mostly followed the vagaries of the market price as best as he could. If jute or cotton or sugar or tobacco or hemp or oil-seeds paid him more, he sowed these crops. It must be admitted that more and more, the peasant was shifting from a subsistence-controlled economy to a money-controlled economy. Commercial crops paid better. Food crops paid less. Fodder crops still less. So, the food resources for both men and animals suffered. The price margin was his only criterion. In this he behaved no differently from entrepreneurs in business or speculators on the stock exchange. In the grip of an individualistic and capitalistic economy, he has no other alternative. The struggle for survival was becoming increasingly severe. It paid him best to do so. After all, he had imperative calls to meet. His revenue, his rent, his ancestral and his own debt are first call on his income. Besides, he has current domestic and ceremonial expenses. He also has to incur productive expenditure in the purchase of cattle, seeds, manure, implements, and the like. For several years, and in the depression period particularly it hardly paid him to grow any crops, including food crops. People generally and consumers particularly are apt readily, to forget this part of the proposition. They procured their food supplies at prices which were ruinous to the cultivator. This will be evident by the following table which shows the price movement of three of the important agricultural commodities in the more prominent markets (relevant), namely wheat at Hapur and Chandausi, gram at Jhansi and Hardoi, and gur at Muzaffarnagar and Gorakhpur, from 1932 to 1937. Harvest prices only are given. It was at this price that the peasant was usually compelled to sell the major portion of his produce.

*Table No. 2—Prices of certain agricultural commodities in some important markets of the United Provinces during the depression years. (Rupees per standard maund.)

Commodities ..	Wheat (April)		Gram (April)		Gur (December)	
	Hapur	Chandausi	Jhansi	Hardoi	Muzaffarnagar	Gorakhpur
Market ..	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Year						
1932	2 7 0	2 4 6	1 11 9	1 14 6	2 10 0	3 8 0
1933	2 14 0	2 12 6	1 13 0	2 4 0	2 12 0	3 13 0
1934	2 4 0	2 7 0	2 1 9	2 5 8	4 0 0	4 7 0
1935	2 7 0	2 7 0	2 3 6	2 0 0	3 12 0	6 8 0
1936	2 10 0	2 10 0	1 12 6	2 0 0	3 4 0	3 4 0
1937	3 4 0	3 3 0	2 10 9	2 1 6	2 8 0	7 0 0

*All prices refer to those ruling in the market concerned, on the last day of the month noted against each commodity. Prices of many other important commodities and of each commodity in many other important markets are regularly compiled by the Department of Economics and Statistics and are published every month in the *United Provinces Government Gazette*.

wants. To grow enough food, within a short period of time, so as to make an appreciable difference to the food situation as a whole, is not easy. But obviously, every little counts. It has to be borne in mind that the "Grow-more-food" campaign must be pressed forward in every way. Happily, a few food-articles like potatoes and vegetables can be increased appreciably to meet particularized needs. In order, therefore, to solve adequately and permanently, the food problem of the nation as a whole, we shall have to radically re-orient our agricultural policy. The Food Conference of the United Nations at Hot Springs, United States of America (May—June, 1943), in which India took an honourable part, lends the hope that the matter of the peoples' dietetic needs, will be regarded as one of the basic subjects for national and international collaboration after the War.

India, even before the war, was not a self-sufficient country. It is a known fact that with the change in the technique of modern warfare, a country, if it is so to stand up to the rigours of war, requires that its structure and peoples be keyed up to certain levels of educational, agricultural, industrial and medical standards. If a country is not so tuned up, it will not find it easy to go through the onslaught of a modern war. This I feel certain is what has happened to this country. Even from the economic point of view, we were not adequately prepared to face the unprecedented calls made upon us. Thanks to our brave Defence, it is well that things have not gone worse with us. Could we, for instance, have stood up to half the death and destruction that was showered down upon the people of Great Britain? I will not contemplate the answer! We were little prepared.

The food aspect is as important and fundamental a factor in the economics of modern warfare as guns and ammunition. We did not visualize the food situation rightly. We awoke to it piecemeal. We thought mainly, first in terms of the army. Then probably, we considered some neighbouring countries. Then we took to thinking provincially. The logic of the situation, due to a complicated variety of factors, has painfully now taught us that the food problem is fundamental. We have also learnt that it is not fractional. The army, the people and the country, and not mere bits of it, have to be treated as a whole. The problem is one and indivisible. We cannot treat the one aspect of the question, neglecting the other. If we do so, we shall do so at our peril. Indisputably, the army stands first. But the nation behind the fighting zone, if we can, in these days of aerial bombardment, so demarcate battle regions, stands close to it. Indeed the army and the people, from whom it springs, are organically one and the same. Food needs of the civilian population have, therefore to be carefully studied. They have to be provided for as part of War programme. Government and people alike, have to educate themselves up to this point. The Home Front, in many respects is no less vital in a totalitarian war, than the actual front. Sacrifices have to be called for from all sides. They must be made, and met.

This implies that we have to view the problem as a whole. Our given food resources must serve our total needs, military and civilian. Deficit areas must be served by surplus areas. Indeed we have to enlarge our horizon further afield. If Ceylon needs rice, we must help to feed it. If

Iran or Iraq need our wheat, we must share it with their peoples. Similarly, if the peoples of India need food supplies, the United Nations, who have surplus stocks of wheat, should spare us some. Shipping difficulties there are, admittedly. But, the dire needs of a people count for not a little. The problem is therefore one. Big views, with big minds, and not parochial views, with little minds, alone can hope to cope with the question, adequately. Then alone can it be solved victoriously. It is then in this perspective that we shall engage ourselves in the study of our local problem, the food needs of our city of Lucknow.

It is not necessary for me to intimate that we have to view this question from an objective point of view, for the present. I do not deny that we should aim at the ideal. Nutritively, we should see that no child in Lucknow is underfed, much less go hungry. Our dietic levels should be improved. Quantitative, as well as qualitative aspects are of co-equal importance. This is an emergent national problem. Vitaminc, nutritive and calorific constituents should be appropriate. Incidence of disease, death and distress would be reduced. Efficiency, health and happiness would be increased. Wastage would be prevented. There is no reason why this ideal should not be set before the nation. In the long period even financially, it would prove successful. Such a food policy would pay for itself ultimately. Agricultural post-war reconstruction must aim at the attainment of this ideal.

We may consider, for illustrative purposes, one item of human diet only, namely, milk. Its importance in the diet of a vegetarian people cannot be exaggerated. Statistics are lamentably wanting on this subject. Yet, it is beyond question that the average daily *per capita* consumption of milk in India is the lowest in the world, being only 9·2 oz. including milk products. The corresponding figure for Canada is 56·8 oz. for Denmark 40·3 oz., for Great Britain 40·7 oz., and for United States of America 35·6 oz.* Even countries like Austria and Italy whose *per capita* consumption of milk is the lowest of all the European countries (being 18·8 oz. and 10·1 oz., respectively) are much better off. The United Provinces have a still lower consumption per head, namely 7·0 oz. per day.†

As can be seen from Table No. 4 the average pre-war daily *per capita* consumption for Lucknow stood at 3·4 oz. of fluid milk plus 14·0 oz. of milk converted into various products, that is, 17·4 oz. in all. This figure compares very favourably with the corresponding all India figure, as well as with the figure for the United Provinces as a whole. It also compares well with the corresponding figures for Cawnpore (15·8 oz. including products). It is slightly less than that for Agra (18·8 oz., including products). Compared with the average urban consumption of 23 cities of India (12·6 oz. including products) again, the figure for Lucknow is much higher. It is regrettable that corresponding figures for war-years are not available. We have, therefore, to remain satisfied with an examination of the pre-war figures only.

*Vide Report on the Marketing of Milk in India and Burma (second edition, 1943), p. 63.

†*Ibid.*, p. 58.

*Table No. 4.—Daily per capita consumption of milk and milk products in Lucknow as compared with other cities of the United Provinces (1935).

Cities	Quantity of milk produced daily in the city	Quantity of milk imported daily from suburbs	Daily consumption of fluid milk	Daily consumption of other milk products in terms of fluid milk	Daily consumption in terms of fluid milk	Daily per capita consumption			
						Fluid milk	Products in terms of fluid milk	Total	Corresponding total for United Provinces as a whole
	Mds.	Mds.	Mds.	Mds.	Mds.	Oz.	Oz.	Oz.	Oz.
Lucknow ..	585	114	2,428	503	3,630	3·4	14·0	17·4	} 7·0†
Cawnpore ..	501	110	1,884	430	2,925	3·3	12·5	15·8	
Agra ..	478	54	2,200	550	3,282	3·0	15·8	18·8	
Average of 23 cities of India	..	..	..	..	..	3·7	8·9	12·6	

* Table based on Appendix III of the "Report on the Marketing of Milk in India and Burma," second edition (1943), pp. 298-99.

† *Ibid.* p. 58. Figure refers to 1940.

In no country in the world is the cow venerated as a sacred animal, and worshipped as such, except in India. One would have thought that this fact would have flooded this land with health giving milk. But the situation is the opposite. We have, therefore, as a people, to re-examine the foundations of our various national beliefs, habits and usages. The children of the poor, for instance, in our cities hardly ever taste milk. Even if they do, it is certainly not pure milk. In the case of Lucknow City, we have seen above, that only about 20 per cent. of the total milk supply is available for consumption as fluid milk. The rest of it is converted into various products, many of which are beyond the means of the poorer classes. The result is that, our sick and aged, pregnant women and nursing mothers, who most need milk and milk diet, get little of it, specially if they happen to be poor. The malnutrition caused by the absence of adequate milk consumption, of good quality, is admittedly one of the major causes of heavy infantile and maternal mortality in this country. The comparatively poor health of the nation in general and of the city people in particular, is traced partly to this lack of sufficient milk consumption. The importance of milk in the diet of the young, has been clearly recognised by modern dieticians. In his Report on the Development of Cattle and Dairy Industries of India (1937), for example, Dr. N. C. Wright has discussed the question of daily *per capita* requirement of milk from a nutritional standpoint. He came to the conclusion that according to existing dietary standards, the production of milk in India should be doubled, in order to meet at least the minimum requirements (15 oz.) for maintenance of satisfactory growth and health of the people. The futility of converting four-fifths of our milk into various products, thus leaving a supply of only about 3·4 oz. *per capita* per day against a minimum requirement of 15 oz. *per capita* per day, can, therefore, be recognized. Suffice it to say that, a better planning of milk supply and milk consumption is the immediate need of the hour. Our forefathers,

centuries ago, had made the discovery of the importance of milk in a peoples' diet. England, even during the present life-and-death struggle, has seen to it that its milk supplies, in spite of being radically reduced by the cutting off of supplies from the continent, were not adversely affected. They made great efforts. They so organised the production and distribution of liquid milk, that even during the period of the war, they have actually increased the consumption of milk *per capita*.* It is one of the most remarkable achievements that will ever stand to the credit of Great Britain. This one illustration should suffice to show that if the nation wills it, and the administration plans it, improvement in the people's diet is not a matter that cannot be achieved. Scientific knowledge, and power of organisation, are not so impotent as not to be able to defeat this foe of human ill-health and misery, namely hunger and want. Thought, energy, money and honesty must be applied, with sustained determination. Thus only can we expect to gather in the fruits of our efforts. We cannot organize all this overnight. But such should be our aim. Some day, let us hope, our people will be fed satisfactorily, both quantitatively and qualitatively.

We must now proceed with our problem. As I mentioned above, ours is an objective study. Like all large and expanding cities, Lucknow depended upon its food supply, not only upon its immediate neighbourhood and district, but also on many other parts of these Provinces. Indeed, it went beyond to other Provinces as well. In regard to basic foodgrains, Lucknow obtained its supplies, in large quantities, from the various districts of the United Provinces and even from the Punjab. Wheat, for example, was imported from the districts of Hardoi, Sitapur, Gonda, Bahraich, Kheri and Basti in the United Provinces and from the Punjab. The same is true of wheat products (*ata, maida, suji*, etc.) also. Rice was obtained from Bahraich, Basti, Nowgarh, Shohratgarh, Barhni and Dehra Dun, etc. Gram was supplied by Gonda, Bahraich, Jhansi, Jalaun, Hardoi, Bara Banki and other districts. Fruits were imported from Naini Tal, Muzaffarpur and Kumaun in the United Provinces and from beyond our Province from Ahmedabad, Nasik, Poona, Nagpur, Kashmir and even as far away as Chaman in Afghanistan.

Lucknow now has to depend on its main staples from within the Province itself. This in itself constitutes some difficulty in obtaining sufficiency of supplies. Commodities normally move from one region to another

* The following authoritative information on the point will be found to be interesting and impressive :

"There has been a considerable increase in milk consumption since the War due partly to the enforced restriction of condensed and dried milk supplies . . . and partly to the cheap milk scheme . . . It was met by diverting larger quantities of milk from the manufacturing to the liquid market, and during the winter of 1941 no milk was used for manufacturing . . ."

"The Ministry is also concerned with improving the quality of milk and has worked out a scheme whereby periodical tests of milk for sourness will be made and advisory visits paid by experts to farmers where the milk produced does not reach the required standard, in order to help farmers, meet the Ministry's requirements . . ."—["Food Control in Great Britain"—Studies and Reports, Series B (Economic Conditions), no. 35 of I. L. O. page 86, published in 1942.]

"Then the available food was distributed in accordance with physiological needs, special measures being taken to ensure that the higher needs of mothers and children and of heavy workers would be met . . . The consumption of milk in working class families has increased by about 20 per cent. the biggest increase being by mothers and children." ("Food and the People," by Sir John Boyd Orr,—page 21, published in 1943.)

only through distinct channels, known as trade channels. These usually work in set ways. Sudden dislocation or suspension of these channels cannot readily be substituted by new ones. New contacts take time to establish themselves. During war such changes naturally take more time. Flow of supplies therefore is impeded. But adjustments have now been made. The position is satisfactory. Much valuable experience has been gained. We should expect progressive improvement in the situation, other things being equal.

Another factor, apart from the source of supplies, is the important matter of the manner in which these supplies are conveyed to the City, physically. It may be noticed from the table given below, that most of the staple food supplies of Lucknow come to it by way of railways. In 1941-42* for example, of the imports into the City, no less than about 52·7 per cent. of wheat, 50·3 per cent. of *ata*, 81·6 per cent. of rice and 53·6 per cent. of paddy was transported to our city by railways. Millets and pulses came over the railways up to 15·9 per cent. The remaining supplies came by way of road.

Table No. 5.—Imports of food articles in Lucknow by rail and by road for 1941-42 and 1942-43 (in maunds)†

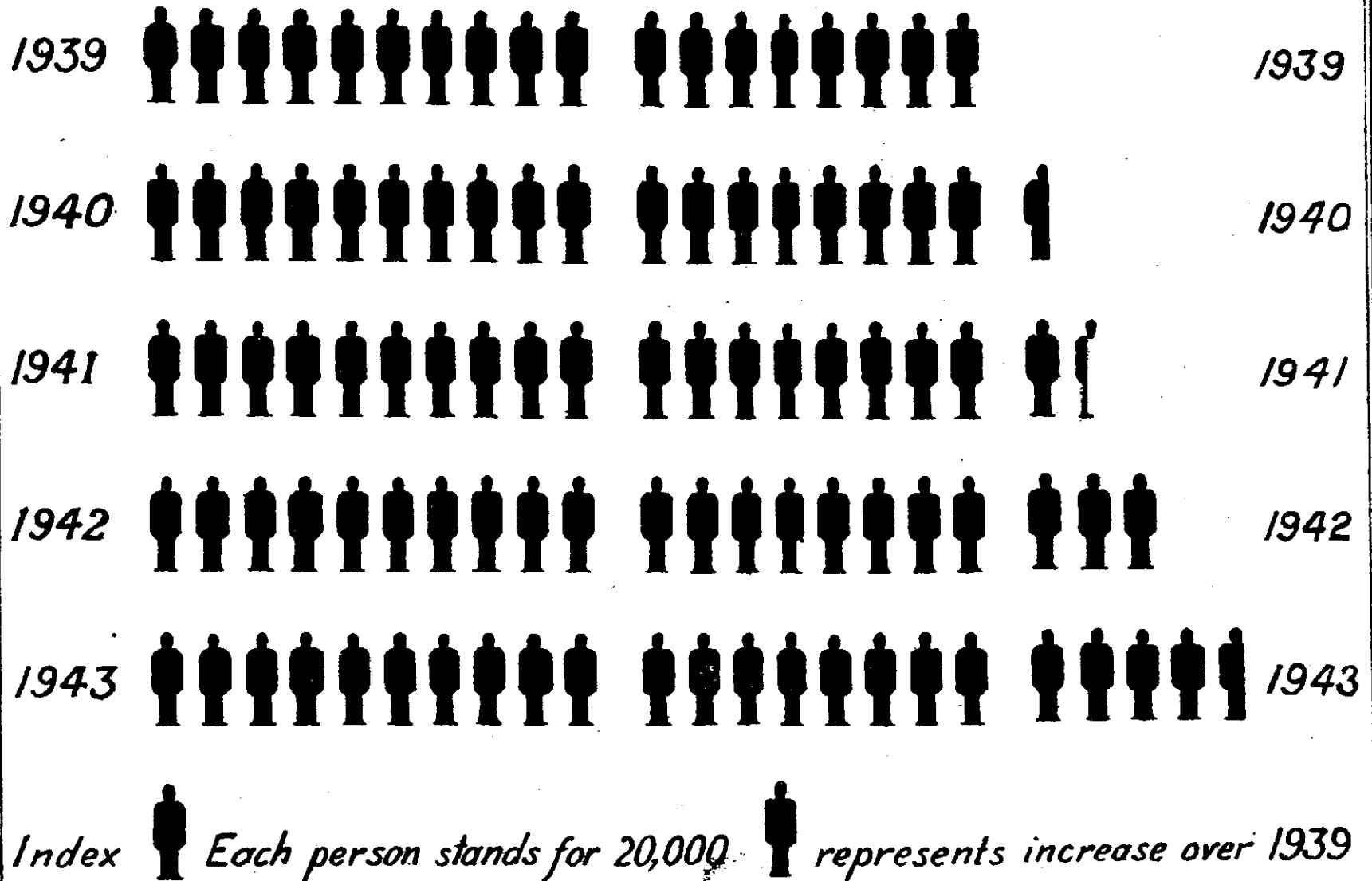
Articles	Total imports		1941-42				1942-43			
	1941-42	1942-43	Imports by rail	Percentage of total imports	Imports by road	Percentage of total imports	Imports by rail	Percentage of total imports	Imports by road	Percentage of total imports
Cereals A..	1,574,360	1,627,705	912,902	58·0	661,458	42·0	867,385	53·3	760,320	46·7
1. Wheat..	982,817	868,279	518,345	52·7	464,472	47·3	475,347	54·7	392,932	45·3
2. <i>Ata</i> , etc.	209,975	244,759	105,602	50·3	104,373	49·7	118,206	48·3	126,553	51·7
3. Rice ..	301,962	402,610	246,310	81·6	55,652	18·4	235,189	58·4	167,421	41·6
4. Paddy, etc.	79,606	112,057	42,645	53·6	36,961	46·4	38,643	34·5	73,414	65·5
5. Cereals B. Millets and pulses, etc.	799,195	1,059,889	127,171	15·9	672,024	84·1	123,451	11·6	936,438	88·4

It may further be noticed that with growing railway transport difficulties subsequently, the quantities of supplies of all articles by rail were considerably reduced. Imports by road increased to a great extent in 1942-43. We recognise the immense calls that have been made upon our railways. When the history of the war comes to be written, Indian Railway Administration will, I trust, come in for due appreciation. They have accomplished a Herculean task imposed upon them. They had at their com-

* Figures for pre-war and earlier war years are not available.

† Total imports, *vide* Municipal records, include imports by rail as well as road. Figures for imports by rail have been compiled from railway records. Figures for imports by road have been obtained by subtracting railway imports from total imports.

I. RISE IN THE POPULATION OF LUCKNOW CITY-1939 TO 1943



I. RISE

1939



1940



1941



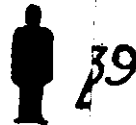
1942



1943



Index



mand limited or, even diminishing plant and equipment. I do not believe that the railway administration was even remotely prepared to meet the terrific traffic demand laid upon it by the exigencies of war. We must recognise the fact that our wagon capacity, locomotive power, personnel, permanent way, cannot all be expanded suddenly. Our locomotive power is our severest limitation. If the reports of the experts had been carried out, and we had commenced building our own locomotives of the broad gauge type, we would have been better able to cope with the traffic problem. The transportation bottleneck must be recognized to be one of the severest handicaps in our internal economy. The food problem has, undoubtedly been gravely aggravated by lack of adequate means of transportation throughout the country. Lucknow has had its share of transport difficulties.

Supplies by way of road into Lucknow, however, have not been impaired to the same degree. Mechanical transport was not much used for bringing in staple foodgrains into the City. It was used mostly to carry fresh fruits and vegetables. To the extent that motor lorries are not now engaged upon this haulage, Lucknow has suffered. But this mostly affects its supplies of fresh fruits and vegetables. Indirectly, however, it also has its effects upon the import of foodgrains. For we have to bear in mind that due to shortage of mechanised transport, bullock-carts have been pressed into all manner of work. Cartage by road is also both slower and costlier. Bullocks have risen greatly in value. In 1930, bullocks of the medium size were sold at Rs. 50 to Rs. 150 per pair in the eastern districts. The present (1944) price is estimated at Rs. 250 to Rs. 500 per pair. The price during the immediately pre-war period, unfortunately, is not available. All this adds to delays and difficulties in transportation, and sends up cost of supplies.

The next fact that we have to consider is the population* that Lucknow has to feed. Before the war, namely in 1939, the population was 361,480. It is now † (December 31, 1943) 454,571, including evacuees. This implies an increase of 25·7 per cent. For purposes of the ration unit, the population has been divided into two categories—adults and children. The adult value, at the rate of one child being equal to half adult, comes to 386,385 in 1943. ‡ If rationing had been adopted in 1938-39, the corresponding adult value of the population in that year would have been 307,258, that is, 25·7 per cent. lower than at present.

In Bombay the population has been divided into three age groups, namely, up to 2 years, 2 years to 12 years and 12 years and over. In more advanced countries they have all manner of division. They go by sexes, by civil condition, and the like. But these are refinements of statistical analysis and administrative fineness which we have not yet attained. Sufficient unto the day!

The floating population of Lucknow I was not able to calculate. This must have increased considerably. § People are attracted to Lucknow

* For details, please see Appendix II.

† According to the second Rationing Census, the population of Lucknow, as on June 1, 1944, has been found to be 430,709, which indicates an increase of 19·2 per cent. over the population in 1939. For explanation, kindly see Appendix II.

‡ Adult value of the population on June 1, 1944, comes to 366,103.

§ It has been roughly estimated at about 5,000 by the Civil Defence Department, (now called the Rationing Department), of the United Provinces Government.

not only for its social amenities, but also for its educational and medical facilities. Administratively too, Lucknow has grown greatly in importance during the period of the war. People must be visiting Lucknow in increasing numbers, in spite of inconveniences of railway travel. All these persons have had to be fed. Our hotels, restaurants, tea shops, café houses, feeding boutiques, *halwais*, *nanbais*, *bhatyaras*, *khonche walas* and the like have all to be kept functioning.

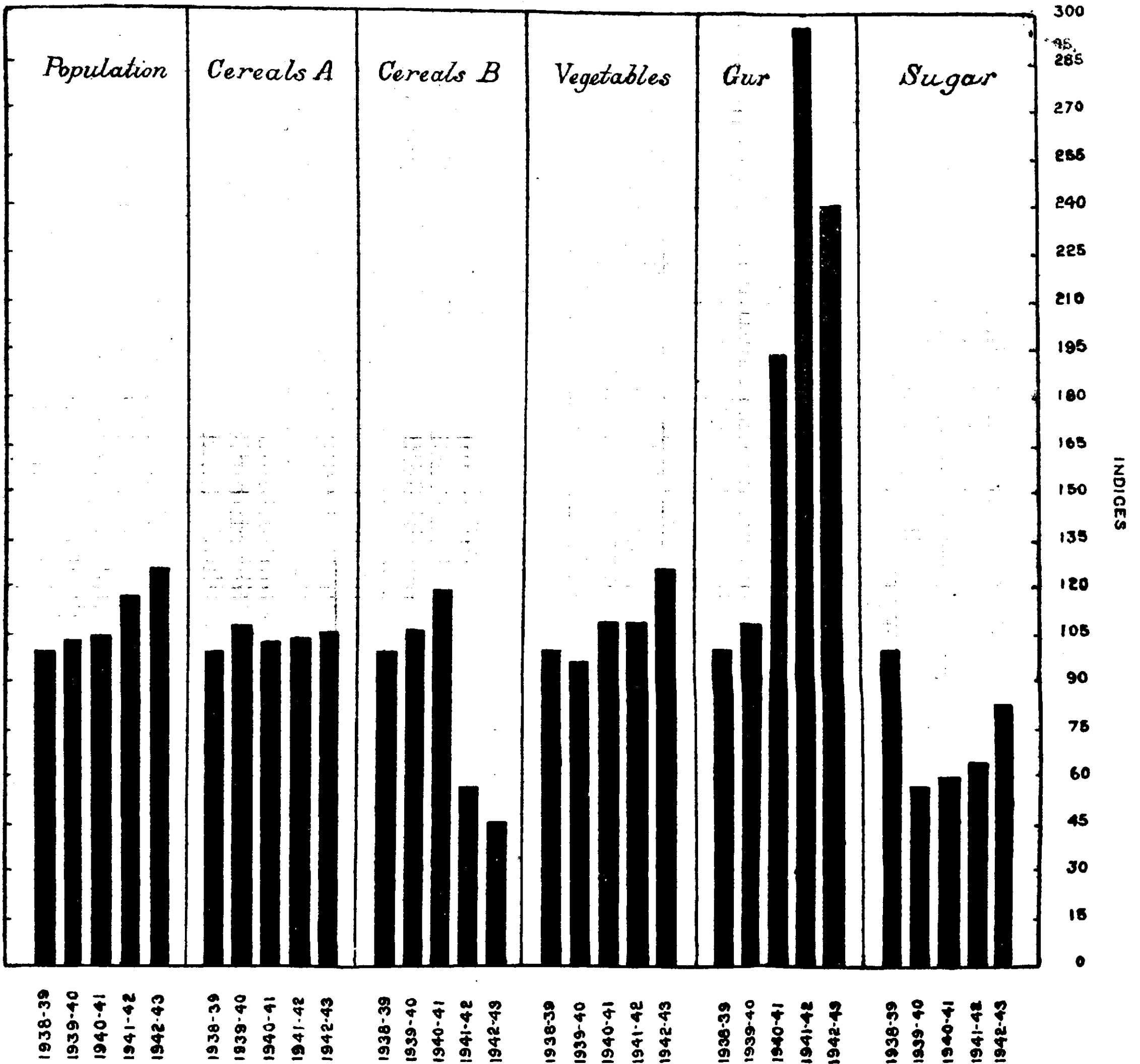
It is, therefore, important to compare the fluctuations in the amounts of our net food supply, and in the population of Lucknow City for corresponding years from 1938-39 to 1942-43. The following table will serve the purpose :

Table No. 6.—Corresponding fluctuations in the net food supply and the population of Lucknow City from 1938-39 to 1942-43 (For further details please see appendices I and II.)

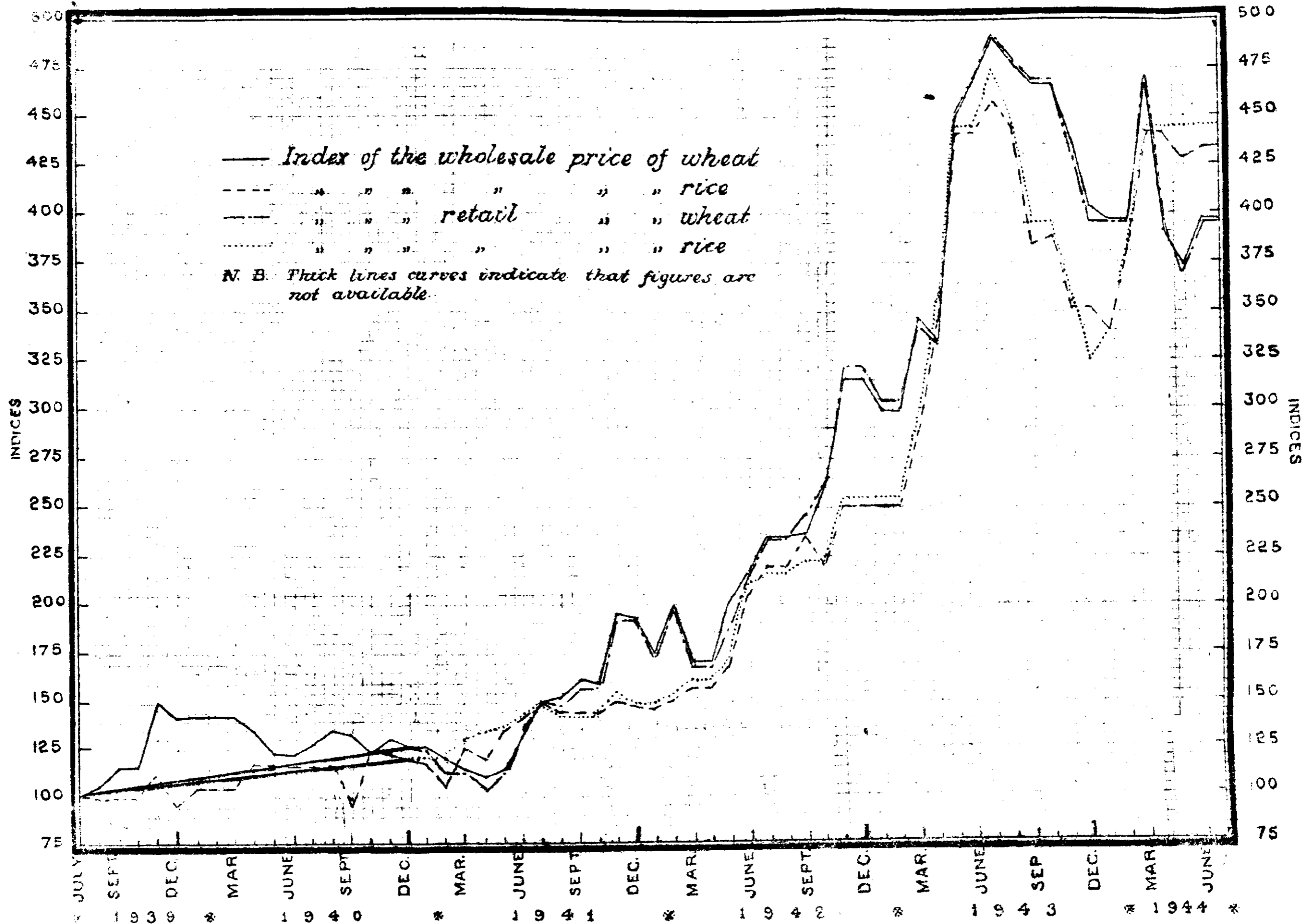
Articles	1938-39		1939-40		1940-41		1941-42		1942-43	
	Net supply	Index no. 1938-39 = 100	Net supply	Index no. 1938-39 = 100	Net supply	Index no. 1938-39 = 100	Net supply	Index no. 1938-39 = 100	Net supply	Index no. 1938-39 = 100
	Mds.		Mds.		Mds.		Mds.		Mds.	
1. Cereals A (wheat, <i>ata</i> , rice and paddy).	1,506,559	100	1,618,172	107·4	1,544,060	102·5	1,556,133	103·3	1,607,292	106·7
2. Cereals B (millets and pulses).	629,367	100	637,601	107·0	738,008	117·3	353,237	56·1	287,402	45·7
3. Vegetables	903,728	100	859,635	96·2	981,431	108·6	982,019	108·7	1,134,487	125·5
4. Sugar ..	155,956	100	85,801	56·1	92,091	59·0	101,262	65·0	130,335	82·6
5. <i>Gur</i> ..	128,548	100	139,722	108·7	243,520	189·4	382,005	297·2	309,971	241·1
6. Population	361,480	100	374,328	103·5	387,177	107·1	420,874	116·4	454,571	125·7
7. Adult values.	307,258	100	318,118	..	329,100	..	357,743	..	386,385	..
8. Years ..	1939	1939 = 100	1940	1939 = 100	1941	1939 = 100	1942	1939 = 100	1943	1939 = 100

We can thus see at a glance, as to what has happened to our supplies in contrast to our increased population. The population of Lucknow (including Cantonment, Ganeshganj, and the City proper) has increased in 1943 by no less than 25·7 per cent. over that in 1939, while the net supply of cereals A (including wheat, *ata*, rice and paddy) has increased only by 6·7 per cent. This indicates the extreme difficulty of the situation. It warrants progressive controls, and extension of rationing. The net supply of millets and pulses, on the other hand, has been reduced to less than half, while that of sugar has decreased by 17·4 per cent. Vegetables have increased by 25·5

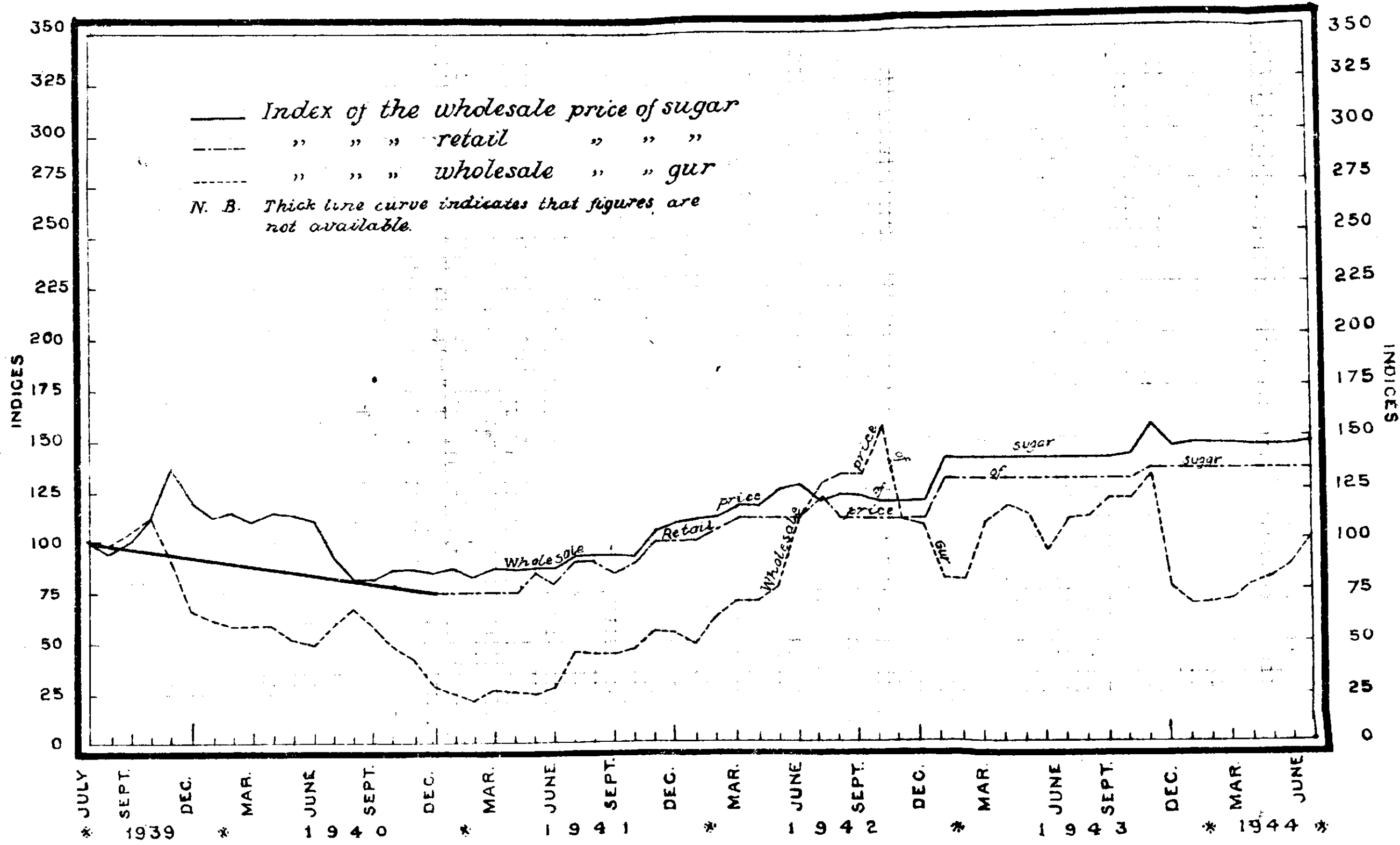
II FLUCTUATIONS IN THE POPULATION AND THE ANNUAL SUPPLY OF IMPORTANT FOOD ARTICLES IN LUCKNOW CITY, 1938-39 TO 1942-43. [BASE: 1938-39 = 100]



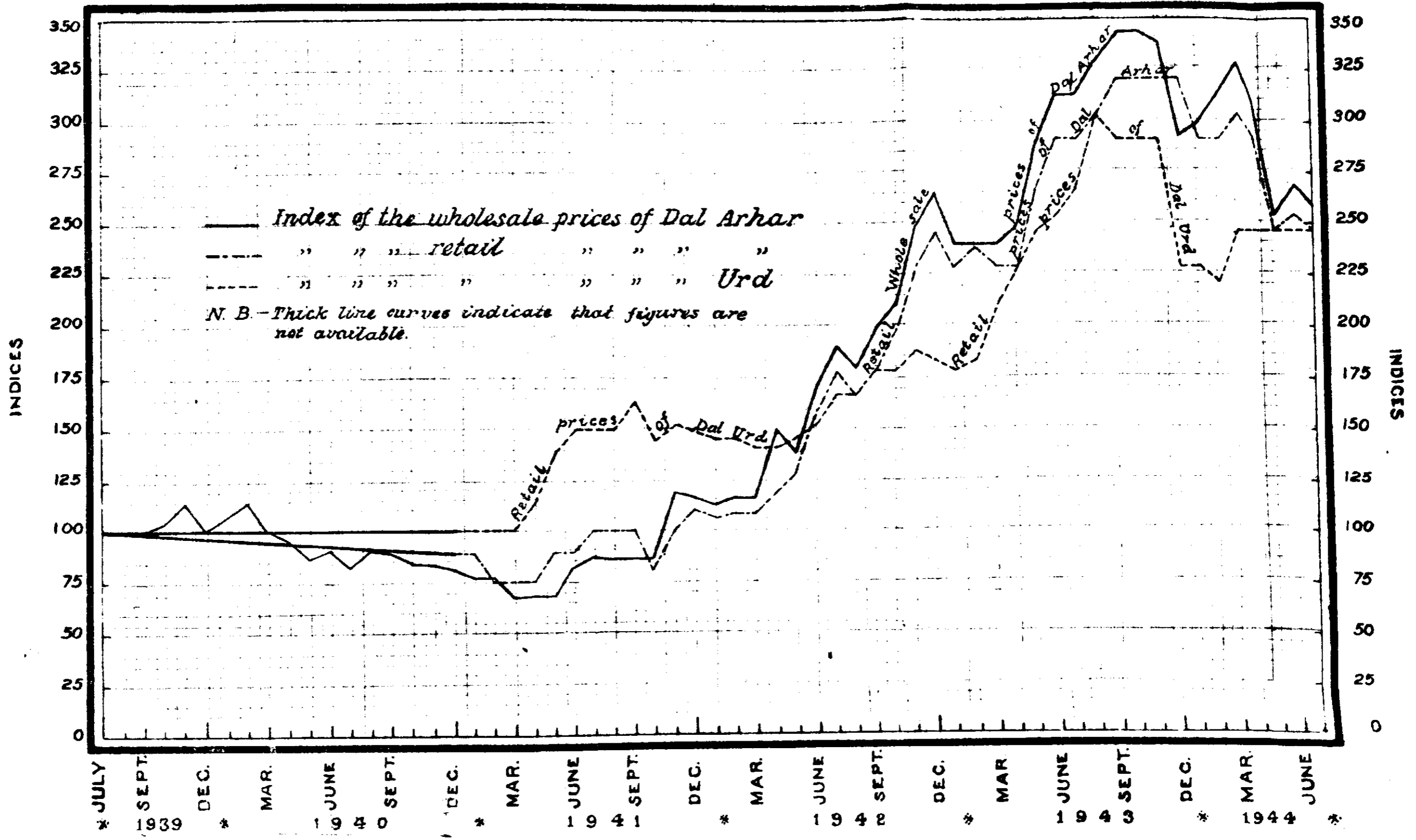
III-A-THE INDICES OF WHOLESALE AND RETAIL PRICES OF WHEAT AND RICE AT LUCKNOW JULY, 1939 TO JULY, 1944. (BASE: JULY, 1939=100).



III-B-THE INDICES OF THE MONTHLY PRICES OF SUGAR (WHOLESALE AND RETAIL) AND GUR (WHOLESALE),
 AT LUCKNOW. JULY 1939 TO JULY 1944. [BASE: JULY 1939 = 100]



III-C-THE INDICES OF MONTHLY PRICES OF DAL ARHAR (WHOLESALE AND RETAIL) AND DAL URD (RETAIL) AT LUCKNOW. JULY 1939 TO JULY 1944 (BASE: JULY 1939 = 100)



per cent. and *gur* by 141.1 per cent. No doubt that there have been variations in the other direction too. The position of millets and pulses, for example, has been much more satisfactory up to 1940-41. The supply of sugar has been comparatively low. Yet the fact remains that except for *gur* and vegetables, no other staple commodity has kept pace with the rising population. In terms of daily *per capita* consumption, the following table will show the position of food supply between 1938-39 and 1942-43. Figures indicate net quantity available per adult unit rather than per head of population :

Table No. 7.—Quantity of food available per adult per day in Lucknow City from 1938-39 to 1942-43 (in chhataks per adult)

Serial no.	Years	1938-39	1939-40	1940-41	1941-42	1942-43	Average
		<i>Articles</i>					
1	Cereals A	8.60	8.92	8.23	7.63	7.29	8.13
2	Cereals B	3.60	3.71	3.93	1.73	1.30	2.85
3	Vegetables	5.16	4.79	5.23	4.81	5.15	5.03
4	Sugar	0.89	0.47	0.49	0.50	0.59	0.59
5	<i>Gur</i>	0.73	0.77	1.30	1.87	1.41	1.22

Information regarding other articles of food (fruits, eggs, poultry, fishes and meat) has been given in Appendix III and regarding salt in Appendix IV.

However, it is not merely a question of volume of supplies. The price factor is also equally important. A history of how the prices (both wholesale as well as retail) of some of the more important food articles have been moving since the beginning of the war at Lucknow, can be easily studied by a perusal of Appendices V and VI on pages 33 to 36 and the corresponding graphs III (a), (b) and (c). For the present, however, we may focus particular attention on some of the more important features of this price-movement, most of which have been summarised in the following tables :

Table No. 8-A.—The annual average price-indices of important food articles at Lucknow, from 1939-40 to 1943-44

Years	1939-40		1940-41		1941-42		1942-43		1943-44	
	Wholesale or retail	Wholesale	Wholesale	Wholesale	Retail	Wholesale	Retail	Wholesale	Retail	
<i>Commodities</i>										
1. Wheat ..	127	123	177	174	315	318	430	429		
2. Rice ..	106	119	154	157	284	286	404	408		
3. <i>Dal arhar</i> ..	101	79	115	109	239	224	311	297		
4. <i>Dal urd</i> ..	..	..	..	149	..	197	..	276
5. Sugar ..	112	86	107	100	130	121	145	133		
6. <i>Gur</i> ..	75	38	61	..	113	..	94	..		

Table No. 8-B.—The minimum and the maximum index levels reached by the monthly wholesale prices of important food articles at Lucknow during each war year.

Years	1939-40		1940-41		1941-42		1942-43		1943-44	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
<i>Commodities</i>										
1. Wheat ..	100	149	108	134	149	215	233	466	373	488
2. Rice ..	94	117	95	141	143	203	218	441	341	458
3. Dal arhar ..	86	113	68	90	86	171	180	313	253	344
4. Sugar ..	98	137	82	92	92	126	119	140	140	155
5. Gur ..	48	111	21	66	44	110	81	155	70	131

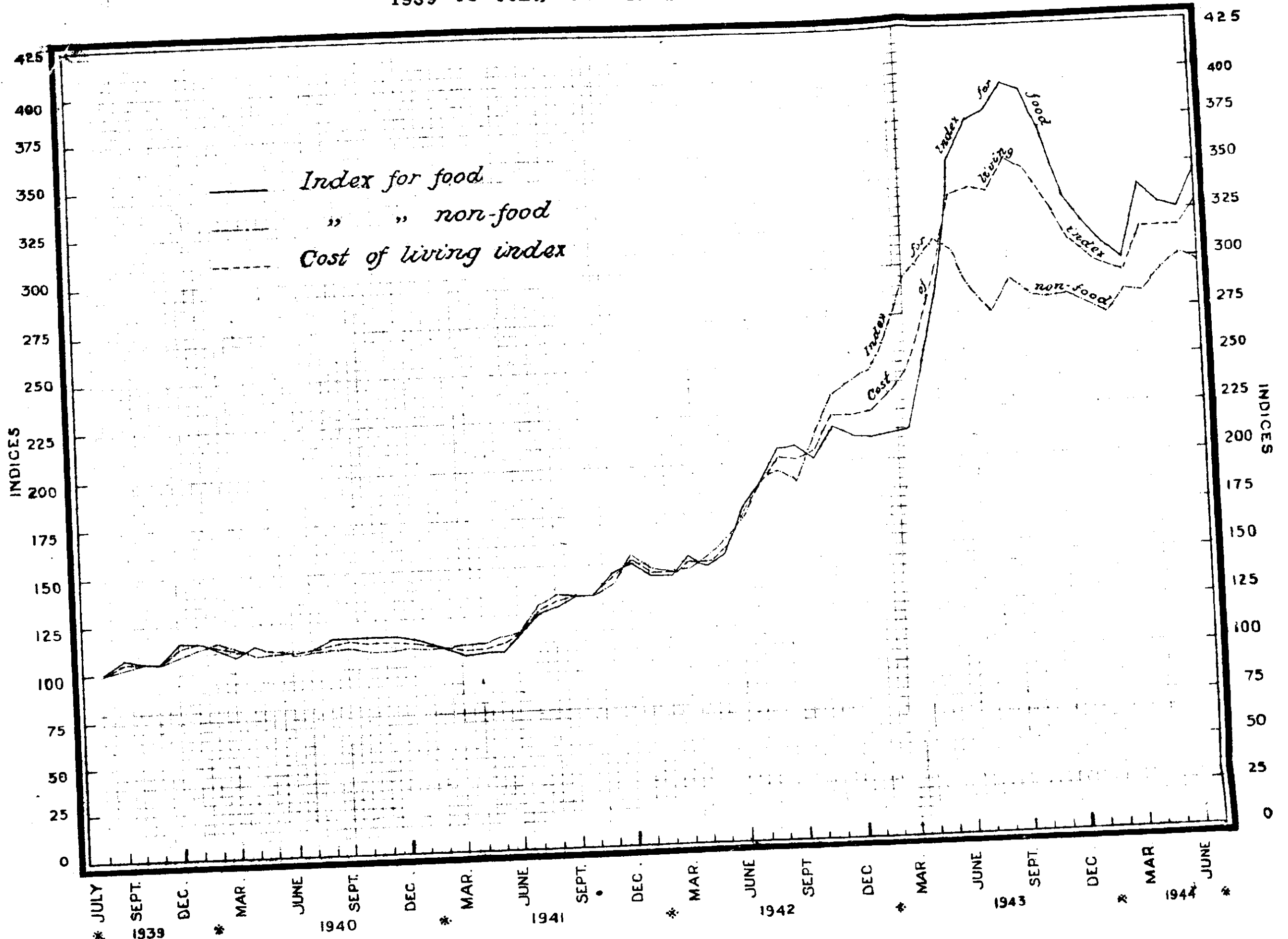
The figures tabulated above reveal a number of interesting features. It was from 1942-43 onwards that the rise in the prices of various commodities assumed serious proportions. All sorts of price control measures had to be taken. Rationing had to be adopted in bigger cities and towns of the Province. Secondly, while the indices for wheat and rice shot up to as high a level as 488 and 458, respectively, the indices for the *dals* did not go beyond 300, except in a few months, particularly during the fifth year of the war (1943-44). Thirdly, the index for sugar has been moving in orderly fashion, while the index of *gur* was unfortunately subject to the most unchecked vagaries of the forces of supply and demand.

On study it will be realised that one of the most potent factors that has influenced the varying tendencies of the price-movement of these commodities, was our serious limitation in regard to transport facilities. Wheat and rice are mostly imported by railways, while *dals* usually come by way of roads from the neighbouring villages. This accounts for the relative scarcity of wheat and rice and the consequent shooting up of their price-indices. On the other hand, sugar has been the most efficiently controlled commodity, since it could be checked at the source and its supplies could be easily regulated on a quota basis for each region. *Gur* had to suffer from an additional disadvantage, namely, its perishable nature. To clear away the huge stocks of *gur* from these Provinces, we required an equally large supply of railway wagons, which we did not possess. This naturally led to a regulated and necessarily slow process of exporting *gur* to other provinces, which, combined with the perishable nature of the commodity, pushed the price to alarmingly low levels at times.

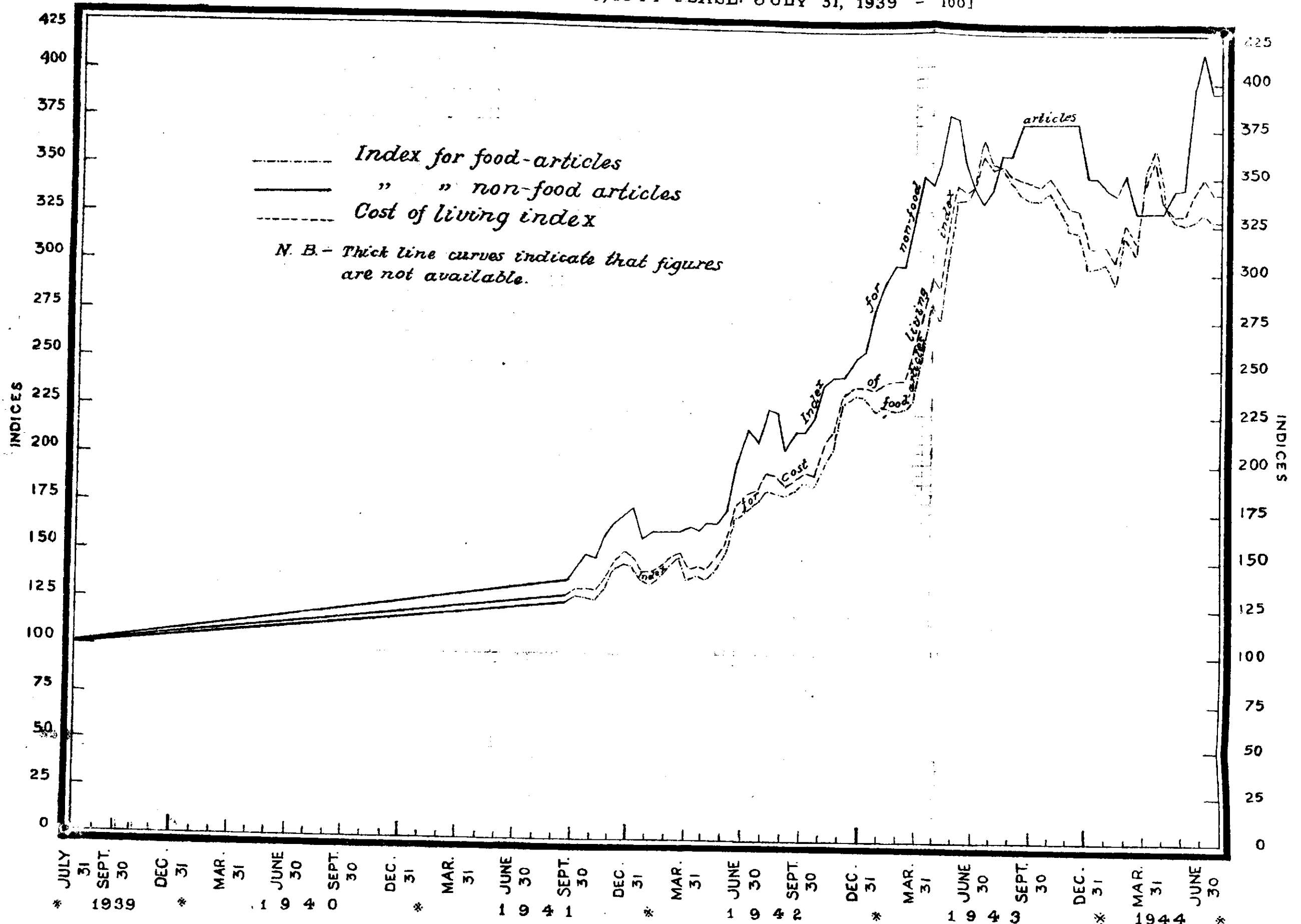
One is, however, struck with another significant feature of these prices. A perusal of Table No. 8-A will reveal that the indices of the retail prices are mostly lower than the corresponding indices of the wholesale prices, except in the case of rice throughout and wheat in 1942-43.

The wheat prices suddenly shot up in the month of March, 1944, consequent upon a psychological reaction on account of untimely rains and hailstorms towards the end of March and the first half of April. Government

IV-MONTHLY WORKING CLASS COST OF LIVING INDEX AT CAWNPORE FROM AUGUST, 1939 TO JULY, 1944 [BASE: AUG., 1939=100]



V-THE FORTNIGHTLY COST OF LIVING INDICES OF LOW-PAID GOVERNMENT EMPLOYEES AT LUCKNOW
 SEPTEMBER, 1941 TO JULY, 1944 [BASE: JULY 31, 1939 = 100]



took immediate step to counteract this unwelcome change, as a result of which the price of wheat again moved down subsequently to the level of the preceding months.

On the whole, however, it cannot be denied, particularly in regard to the years 1942-43 and onwards, that the consumer was hit hard. Rising prices must inevitably impinge upon the standards of living of the community. Those of low-income groups, and especially on fixed salaries, suffer the severest in times of rising prices. We do not know the income distribution of Lucknow City. While it is the city of Rajas and Nawabs, it is also the home of the humble and the poor. The paradox of economics often is that concentration of greatest wealth goes alongside with the existence of abject poverty. This may be true of Lucknow City also. We have no cost of living index number for Lucknow in general. However, we have such an index for the neighbouring city of Cawnpore, for mill-workers. We have also one for low-paid Government employees* in Lucknow. We can, therefore, measure to some extent, how the cost of living has been fluctuating during these years of stress and strain.

The following table shows the annual average index numbers for food articles, non-food articles and the general cost of living for the working classes at Cawnpore and the low-paid Government servants at Lucknow :

TABLE NO. 9-A

Year	1939-40		1940-41		1941-42		1942-43		1943-44	
	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov
<i>Group head</i>										
1. Food ..	108	..	111	..	144	139	230	236	347	331
2. Non-Food ..	108	..	109	..	145	162	250	279	285	357
3. General cost of living index.	108	..	110	..	145	144	238	246	323	337

THE following table gives the minimum and the maximum levels which the indices for food, non-food and general cost of living at Cawnpore and Lucknow reached in any month or fortnight respectively in each of the war years :

TABLE NO. 9-B

Year	1939-40		1940-41		1941-42		1942-43		1943-44		
	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	Cawn-pore	Luck-nov	
<i>Group head</i>											
1. Food	Min. ..	100	..	105	..	125	125	190	178	298	295
	Max. ..	115	..	115	..	176	174	354	345	393	368
2. Non-food.	Min. ..	100	..	107	..	128	137	192	209	275	332
	Max. ..	114	..	114	..	174	216	314	380	300	403
3. General cost of living index.	Min. ..	100	..	106	..	126	128	191	185	294	305
	Max. ..	114	..	114	..	175	183	336	345	353	361

* These include only those getting Rs. 30 or less per month.

It will be quite evident from the above figures that like the prices of food-articles, the cost of living too assumed serious proportions in 1942-43 and onwards. It is, however, significant to note in Table No. 9-A that, while in 1942-43 the index for non-food articles was higher than the index for food articles, both at Cawnpore and Lucknow, and was thus more responsible for raising the cost of living, in 1943-44 the tendency had been reversed at Cawnpore, while at Lucknow both the food and the non-food indices shot up at a rapid pace.

Whether it was due to food articles or to non-food articles, the fact remains that the cost of living has gone up to a high level, at which it is difficult for a majority of the people to make both ends meet. In the ordinary man's language we can have an idea of the hardship caused to the masses by measuring the purchasing power of the rupee in terms of commodities. Thus, if in the pre-war period, a rupee could purchase commodities worth 16 annas, on the average, in each of the subsequent war years the same rupee could purchase commodities worth annas given in the following table, at Cawnpore and Lucknow :

Year		Pre-war value	1939-40	1940-41	1941-42	1942-43	1943-44
			As. p.	As. p.	As. p.	As. p.	As. p.	As. p.
1. Cawnpore	.. ..	16 0	14 10	14 7	11 0	6 8	4 11
2. Lucknow	.. ..	16 0	..	..	11 1	6 6	4 9

The above figures clearly indicate that a man getting Re. 1 per day as his wages in 1943-44 was as good as a man getting 4 annas 11 pies at Cawnpore or 4 annas 9 pies at Lucknow per day in the pre-war period.

To meet the enhanced cost of living, there are arrangements promulgated in advanced countries of the world, to assist the poorer sections of the nation. Apart from price stops, which are effective, widespread grants to certain categories of people are given. These are allocated directly or indirectly by way of dearness allowances or subsidies. To some extent this is being done in India also. Our Government has done its share. At the moment it is costing Government quite heavily. An idea of the loss incurred by Government on this account can be had from the following comparative rates of various food-articles at the Government ration shops and in the open-market, as on August 31, 1944 (the latest) :

Rates in srs. per Re.	Wheat	Barley	Gram	Jowar	Bajra	Rice	Ata
	Sr. ch.	Sr. ch.	Sr. ch.	Sr. ch.	Sr. ch.	Sr. ch.	Sr. ch.
1. Open market	.. 3 0	.. 5 8	.. ..	.. ..	.. ..	.. ..	.. ..
2. Ration shops	.. 4 0	.. 6 8	.. 5 8	.. 5 10	.. 5 8	.. 1 8 .. 2 4 .. 2 8	.. 4 0

Open market rates of the comparable qualities of gram, jowar, bajra, rice and ata are not available.

On the other hand, it should be borne in mind that some sections of the community, e.g. all manner of skilled workers, general labourers, artisans, domestic servants and the like are earning higher wages. They are thus expected to meet the burden of enhanced prices. There is no question of lack of employment. In fact, there is great dearth of labour, skilled and unskilled, in all categories of occupation. Family incomes must have increased. This would help the family budget.

It is people on fixed salaries, the middle and the lower middle classes, whose women do not engage in employment in India, and whose children continue at school or college, and who are not covered by dearness allowances, that suffer most. Such categories of people mostly reside in towns and cities. They form a substantial portion of any Indian city. In a provincial headquarters and a city of the type of Lucknow, their number must be considerable. They deserve particular attention. We have, unfortunately, little concrete knowledge about their present economic condition. University students and the Economics Department of the several Colleges located in this City, could render a timely and useful bit of public service, if they carried out some surveys. Much-needed light would be thrown on a live problem. I commend this to the consideration of the authorities concerned. We in the Department of Economics and Statistics in Government, would be happy to extend such help as we can in such research.

The abnormal rise in prices, specially of the essentials of life, creates a situation, in which the State has to interfere. Things cannot be left to the mere mercy of economic forces. Supply and demand and open market operations cannot be allowed to function as they will. All manner of controls have to be introduced. One of these is rationing. Rationing functions on the pre-arrangement of several important and complicated processes. It is also a problem in economic organization. The question has to be considered as much from the side of supply as from the aspect of actual distribution. In this lecture, however, we must take these for granted. In short, we have to accept the proposition that when there is great scarcity in the community, of any given essential commodity, and prices soar, and purchasing power in the hands of the *mass* of the people does not increase proportionately, the only manner in which equitable distribution can be ensured, is by a process of rationing. There is no other way in which this can be achieved.

Rationing is a difficult and intricate process. It demands high degree of administrative ability and efficiency. It also requires high degree of honesty. Equally indispensably, it depends much upon intelligent collaboration from the public. These conditions cannot be produced to order. They take time to emerge. Frankly also, much depends upon civic and psychological factors. But in times of economic stress, such as these war years, rationing is the only solution. Indeed, for the poor and the low-paid sections of the people, there is no other alternative. This is the only means to ensure supplies of the essentials of life to the community at large. Total rationing would be ideal. This is being contemplated for cities having a population above one lakh persons. Short of this, partial rationing is the next best alternative. Happily, the public in the United

Provinces have begun to realise this. They have now slowly become "ration-minded"; Government too have come to see that public co-operation, advice and assistance are highly desirable. Such co-operation is progressively necessary for a successful working of the rationing scheme in our towns and cities.

Incidentally, it may be mentioned that the problem of rationing the rural population would be immense. We assume that they can rely upon their own resources. Personally I am not too sure of this. In respect to certain categories of our village population I am doubtful whether they can keep themselves in foodgrains all the year round. In fact, for certain types of villages, specially near towns and cities, and for certain classes of people in all villages, the question of food supplies must be difficult, if not acute, at least for some period in the year. This must be especially so for the unskilled and landless labourers, and for those who hold what are known as uneconomic holdings.

A ration system should aim at giving per age, and wherever possible, according to vital circumstances, a unit of ration, sufficient in quantity, and adequate in quality, to meet the physical needs of the average consumer. This is heavy responsibility. In case of shortage, of course, this programme cannot be followed. The best that can be done is to equitably distribute the scarce supplies. In the case of the City of Lucknow, the average quantity available per adult in 1942-43 was 7.29 chattaks of cereals A and 1.30 chattaks of cereals B, under an equitable distribution. Under the Government rationing scheme, it is therefore, gratifying to note that every adult member of the rationed population is allowed to purchase a ration up to a combined maximum of 12 chattaks per day as follows :

TABLE No. 10

Commodity	Maximum limit allowed per adult unit per day—(In chhataks)				
	Up to 13th December, 1943	Up to 18th January, 1944	Up to March 31, 1944	Up to July 31, 1944	August 1, 1944 onwards
(1)	(2)	(3)	(4)	(5)	(6)
Wheat ..	6	8	12	6	4†
Gram ..	6	8	12	12	12
3. Barley ..	6	8	12	12	12
4. Rice ..	8	8	6*	4	4
5. Millets ..	12	12	2	12	12
8. <i>Ata</i> ..	12	12	12	12	12

It is evident from these statistics that, leaving aside the question of the purchasing power of the people, on the supply side at least, the poorer sections of the population were always offered a higher combination of food

* Quantity of rice was reduced to 4 chtk. as from June 3, 1944.

† Quantity reduced for general public only. Factory workers and railway employees are still allowed to draw 6 chtk. of wheat per adult unit per day.

articles than even the most equitable distribution under a *laissez faire* economy could have guaranteed.* This system of rationing can therefore be regarded as satisfactory, viewed exclusively from this aspect of supplies.

In India, I suppose if the quantitative factor alone is sufficiently provided, it would mean much. Qualitatively, as I have already mentioned above, we have not even begun to think of the question. But if the war should last long, which we pray it does not, the qualitative factor will become increasingly important. We will not be able to neglect it for long. I am not too sure whether even now it is not necessary for us to examine the qualitative position. I am, of course, not thinking crudely in the matter of removal of impurities, earth and weevil and the like. Government is concerned about the matter of purity of foodgrains supplied to the public. It is their responsibility. Active steps are being taken to ensure improvement in this direction. To the best of my knowledge quality of rationed food grains has greatly improved in recent months. I am, however, concerned about the question of quality, from the point of view of a balanced diet. We should endeavour to see that in these days of high prices, the average consumer is able to secure for himself the necessary elements that would constitute a nutritive diet. With this end in view, we may have to start on what is known as "differential" rationing. To some extent we are doing this even now. For instance, according to the present ration unit, the factory workers and the railway employees are allowed to get daily 6 chtks. of wheat per adult unit, while the general public can get only 4 chtks. per adult unit. We need to consider particularly men and women engaged upon essential services and occupations. Their physical fitness is of importance to the nation. The problem has even now emerged, to some degree, in respect to our labour in the coal-fields. Inadequate supplies of rice rations have led to a fall in the raising of coal. We know that in several foreign countries, systems of differential rationing have been in progress in various ways to ensure the maintenance of physical fitness of the labour engaged upon essential services. Next to such categories, I would plead for pregnant women, nursing mothers, infants, children and our youth. They are the "vulnerable" part of the nation. They are the future generation. We have to safeguard their health. Their vitality and growth should not be impaired. This is no easy task. We should apply our minds to this aspect of the national problem now. It is important, if not vital, for the future. It was gratifying to see the stress laid on this aspect of the problem by the United Nations Food Conference at Hotsprings.

Apart from the question of the adequacy of the ration unit, quantitatively and qualitatively, we cannot disregard the price factor. The price fixed for the various commodities should be such as may be within the reach of the poorer section of the community. The ration cards entitling the owner to buy certain quantities of foodgrains would be of little comfort to him, if the rates at which those are sold are beyond his means. He cannot indefinitely incur debt for daily needs. This is, therefore, matter of importance. It has implications of a serious order for Government in respect to financial obligations involved. The State needs must examine this with

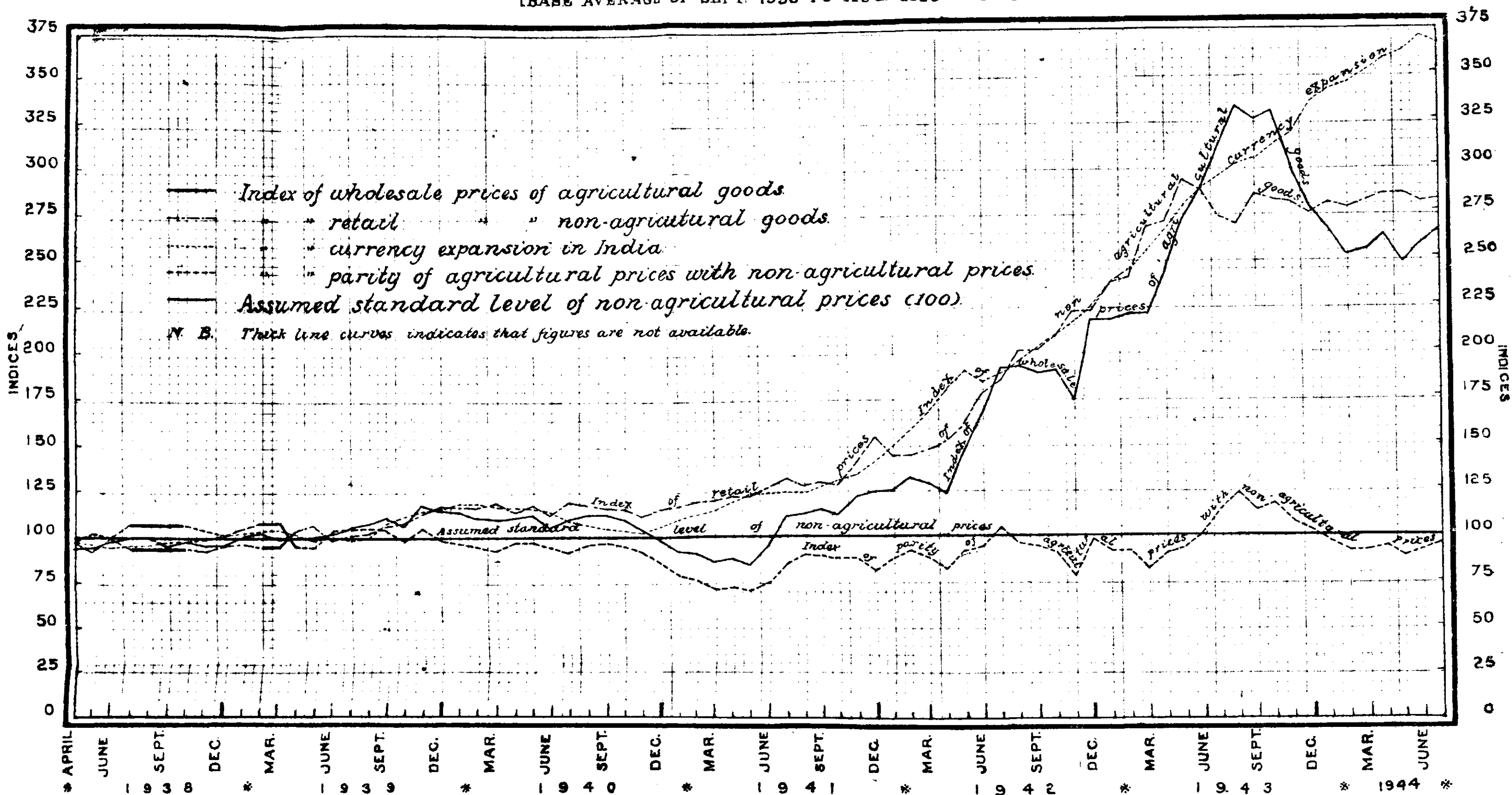
*A specimen of the ration cards entitling the holder thereof to get supplies from ration shops is given in Appendix IX.

caution. But under circumstances, when prices of the essentials of life, and especially of food, go beyond a given range, the State cannot but regard the situation with concern. The vitality of the ration and especially of the younger generation, has to be maintained. The poor become the particular concern of the State. Price stops have to be imposed. Such imposition, however, must examine with care the re-action to supplies. If unfavourable, subsidy would be indicated. Such payment is not easy to determine. It involves close calculation of cost of cultivation and other factors. The primary producers themselves are of different categories. However, the principles and the methods of payment of such subsidies is no new matter. It has only to be worked out and applied to our special circumstances.

Consumers too, of given classes, require consideration. We can earmark these by income groups. The wealthy and the well-off can look after themselves. Subsidized sales could be made only to people of given income groups. Or, in the alternative, given commodities of given quality, which are consumed mainly, if not exclusively, by the poor can be subsidized. If any case, the price factor is important. Wealthy nations like Great Britain have adopted subsidies on generous scale. In India the situation clearly requires study. Active assistance is already being given in increasing measure. In Lucknow City itself, the need for such help may not prove unwarranted. Indeed the rates at which certain foodgrains in our present ration system are sold to the public, show that the authorities have not been oblivious to this important matter of cost of food to the poorer sections of the community. The rates of various foodgrains, charged at the Government ration shops, are well below the open-market rates.

Supplies are fundamental to the process of rationing. The first requisite is that there should be enhanced production to meet the greatly enhanced demand. "Grow More Food" is a campaign that has to be pressed forward, all the while. We need not analyse the causes of enlarged demand. The fact, however, has to be accepted. Apart from a patriotic appeal to the cultivators of the soil, economic inducement is the only thing that in India, under the present circumstances, can really be the most effective. The cultivator, while being grain-minded, is not impervious to the attraction of money. Our peasants, being illiterate, are highly conservative in their notions of things. In respect to money, for instance, they believe in the intrinsic worth of the currency. They have little faith in its "representative" character. They are not arm-chair economists regarding money. Indeed, many better educated persons, too, often think and act in like manner. Hence no amount of argument will shake them out of their set notions. Peasants, in a sense, are bullionists. It must also be recognised that they are the masters of our economy. This is a supreme point that can never be lost sight of in all our food policies. Unless, therefore, Government elects to come down to their level of thought in this regard, and makes necessary adjustments in the character of the currency, we shall be trying to run our economy, as it were, with breaks on. The currency requires to be saturated a good deal with metallic money, especially silver. Gold is little good for grain supplies. As an illustration of this fact, it has been observed that grain in some of our cities and villages

VI-INDICES OF MONTHLY WHOLESALE PRICES OF AGRICULTURAL PRODUCTS AND RETAIL PRICES OF NON-AGRICULTURAL GOODS AT CAWNPORE OF THEIR PARITY AND OF THE CORRESPONDING CURRENCY EXPANSION IN INDIA. APRIL 1938 TO JULY 1944. (BASE AVERAGE OF SEPT. 1938 TO AUG. 1939 = 100).



has been sold at different rates in return for different types of currency used in the same market at the same time.*

The next matter in which the unlettered peasant has shown commendable sense, is in the appraisalment of the comparative value of non-agricultural commodities, in parity with their own produce. They have come to realise that the prices of their own produce have gone up, and are naturally happy about it. But they do not stop there. They calculate and convert the price for their produce, which they readily do, in terms of cost of articles they need. They find that these articles, mostly manufactures, have gone up in prices even more—much more—than their agricultural produce. They are, therefore, not so pleased. They compare, for instance, the prices of *dhotis* and *saries* and shirtings, with what they used to be, and what they were a few months back and are now. They also see, for they are not so dull and non-observant, that many of the things they need, they cannot even obtain. For instance, they need kerosene oil. They cannot secure it except under considerable difficulties. So they naturally hold up their produce for better prices. Our Department had occasion to calculate indices for agricultural wholesale prices and non-agricultural retail prices at Cawnpore.† This analysis supports these observations beyond doubt. It was found that the non-agricultural prices were higher than the agricultural prices from 1940, more or less continuously until May, 1943. This parity altered in favour of agricultural commodities since June, 1943 onwards. From October, 1943, however, the agricultural wholesale prices have been declining, while the corresponding non-agricultural retail prices have recorded a slight rise, however small, so that by December, 1943, the former receded back to come together again with the latter. The year 1944 has shown considerable fluctuations in the price-level of agricultural commodities. On the other hand, the index for non-agricultural goods has been, on the whole, moving upwards. Compared with the levels in December, 1943, the agricultural commodities recorded the maximum fall of 30 points in May, 1944. Against this, the non-agricultural goods rose by 9 points. The agricultural prices have indicated an upward tendency subsequently. Yet the parity index did not push up beyond 95 even in July, 1944†.

Requisition has been suggested as a solution of the problem of increasing supplies. But it cannot be recommended. We have no time to proceed with the examination of this very intricate and dangerous proposal today. It might be mentioned in passing that requisition did not succeed in Russia. It is unlikely to succeed in India. The only way to guarantee proper flow of agricultural produce is the offer of satisfactory economic inducement. To determine this, several important factors have to be taken into account. Allowance, for instance, will have to be made for

*At a meeting of the Provincial Economic Advisory Board, United Provinces, held on December 3, 1943 at the Council House, Lucknow, no less a person than Lieut.-Colonel Dr. Sir Ziauddin Ahmad said that the price of wheat was linked up with the value of the paper rupee, so much so that in Aligarh a silver rupee bought 5 seers, small coins 4 seers and a paper rupee only 2½ or 3 seers of wheat. It was, therefore, necessary to restore confidence in the paper rupee, by fixing its value in terms of silver.

†Please see Appendix X for details.)

higher cost of production. Bullock-power, man-power, implements and the like have all gone up in cost. Parity with non-agricultural commodities will have to be studied and appropriately regulated. Payment in currency that is readily acceptable to the peasant will have to be provided.

With victory in sight, supplies should arrive in increasing abundance. Government have already taken steps in the matter of bringing down prices of non-agricultural commodities. Such a tendency must have, in due course, its desired result. Peasants have postponed purchases. They have secured good value for their produce. They have the wherewithal to buy with. They will be eager to purchase, both consumable and productive goods. Speculative tendencies and hoarding habits cannot stand against a declining price level.

Apart from the primary producers, there are dealers and retailers who have to be considered. There is an army of them. They are of baffling varieties and categories. Some regulations have already come into operation in this connection. Experience will reveal the weak points. Improvement can always be introduced. Regulations can be made more equitable to all concerned.

The process of securing supplies from the primary producer, from the smaller and the larger *mandis*, and to import these into the consuming centres is a delicate and risk-entailing business. Thousands of middlemen with age-long experience, accumulation of technical knowledge, financial resources, traditional contacts and customary usages perform this intricate service. They keep, carry and convey the produce, not only from place to place, but also from one season of the year to another. Even the storage and physical safe-keeping of the produce is no easy task. The risks involved are considerable. Physical loss or deterioration of grain through inadequate arrangements are obvious. Price fluctuations and other economic factors have to be safeguarded against. All this involves all manner of sales and speculative operations. The cost entailed is heavy. The margins of profit, in normal times, were not too big. It is thus that the produce reached the cities, and finally into the hands of the ultimate consumer himself. A substantial portion of the work of buying, storing, despatching and selling in certain *mandis* and towns has been taken over by Government, under its own direct control and supervision in our Province, employing trade channels. It has left some room to certain types of dealers. If our trades people, both wholesale dealers and retailers, had been better organized, and if our banks too had a concerted policy, I feel certain that Government would have been greatly helped and assisted. In the absence of such organization, and in the presence of divergent interests and lack of mutual trust, which is fundamental to the whole process of control, the agency of trade could not be so fully utilized as it might have been. It is to be hoped that trade will take note and put its house in order.* Standards of dealing should be evolved and established. These should be able to stand the test of the severest scrutiny. These conditions, it must be confessed, are largely absent at present. Short weight,

*One is happy to record that within two months after the paper had been read, the United Provinces Traders' Conference was held at Lucknow, on January 21, 1944 for this very purpose. They have now set up a representative organization, known as the United Provinces Beopar Mandal.

bad quality, absence of grades and other abuses abound. Our marketing practices in respect to our agricultural staples, and foodgrains in particular, need overhauling. Our reputation in markets abroad is lamentably low. We need to modernize our marketing methods. In times of stress such as these, when prices have risen steeply, all the weaknesses of such out-dated and out-moded methods of dealings come up to the forefront in an acute and distressing manner. However, in face of serious war emergency, Government had to take quick action to safeguard the situation and take control.

The present process of procurement is that approved purchasing agents purchase on behalf of Government, at given prices, arrivals of foodgrains required, at given *mandis*. The Regional Food Controllers are officers who secure supplies and regulate its despatch. The movement of foodgrains and other articles of consumption within the Province are controlled regionwise. All export out of the Province is also controlled. In Lucknow, purchase by the public is possible at (1) Ganeshganj-Fatehganj, (2) Hasan-ganj, (3) Daliganj, (4) Sadatganj, and (5) Pandeganj-Daulatganj. Foodgrains on behalf of the Government are now held by the District Magistrates concerned for their respective districts, while formerly they used to be held by the Imperial Bank also. Quantities needed are brought to an issue godown. Here the stuff is cleaned, weighed and sold to licensed retailers. There are 110 approved ration shops in the city, located strategically, to serve the needs of the six areas into which the city has been divided for ration purposes. At present 81·1 per cent. of the population is being served, out of which every 100 persons constitute about 83 public, 4·6 factory workers, and 12·4 railway employees*. At these ration shops, rationed foodgrains are sold to ration-card holders, up to units indicated for the respective grains. Prices are so fixed as are comparatively favourable to the consumers. The policy is progressively to reduce rates charged, so as to lead the market prices downwards.

The supply and distribution system in connection with rationing is elaborate. The machinery is being improved daily. Even as one writes, the system undergoes change. Improvement is progressive, especially from the supervision aspect. The staff engaged is of various ranks, with specific functions. On the distribution side, there is the Town Rationing Officer, two Deputy Town Rationing Officers, four Area Rationing Officers, with a whole host of senior inspectors, inspectors, enquiry inspectors, and other staff. Every effort is made that the staff works arduously and honestly, as well as courteously.

It is at this point, I think more than at another, that public co-operation would be of greatest value. However industrious, honest and capable the officials may be, we still need the hand of help from the public itself. May I take this opportunity to bear public testimony to the arduous and ceaseless work put in by officers—European and Indian, high and low—at the seat of the Government and throughout the Province. In the Secretariat, they have laboured with indefatigable industry and with

*For details, please see Appendix II. The figures are correct as on June 9, 1944. Every succeeding week brings larger numbers under rationing service.

commendable ability. Most of them have worked with praiseworthy honesty. Those who have laid down policy have done so with an eye to public weal.

In all foreign countries, and in several places in India itself, help by the non-officials has been readily given. Economists everywhere in the country have pleaded for such constructive co-operation. It is a happy aspect of the matter that this is being increasingly appreciated by Government itself. Associations like the Lucknow Social Service League, having intimate knowledge of local conditions, can help a great deal. They know the circumstances of families and even of individuals. They could supplement useful information already in possession of Government. In the matter of supervision, too, great help could be rendered. In a country where the poor are generally unlettered, where women are secluded and ill-informed, where sectional favouritism is not unknown, where the petty officials are too officious, the help of Associations like these, composed of well-informed and public-spirited men and women, would be of great moment. Help of women would be of great benefit. May I say that women can render even greater service than men in this particular matter of food. It is to be hoped that by collecting information, sitting on Government bodies and the like, help will be forthcoming. It is a unique opportunity for service. I feel certain it will be made use of by the men and women of the City of Lucknow.

APPENDICES

APPENDIX I

The supply of important food articles to Lucknow City, from 1938-39 to 1943-1944

(Figures in maunds.)

Food articles	1938-39			1939-40			1940-41			1941-42			1942-43			1943-44 ||			Food articles
	Imports*	Exports†	Net available for consumption	Imports*	Exports†	Net available for consumption	Imports*	Exports†	Net available for consumption	Imports*	Exports†	Net available for consumption	Imports*	Exports†	Net available for consumption	Imports||	Exports†	Net available for consumption	
CEREALS A ..	1,524,784	..	1,506,559	1,636,307	..	1,618,172	1,562,285	..	1,544,060	1,574,360	18,226	1,556,135	1,627,705	20,413	1,607,292	1,235,074	..	..	CEREALS A
1. Wheat ..	1,059,239	..	1,048,141	971,904	..	960,806	963,482	..	952,384	982,817	11,008	971,719	868,379	7,862	860,417	894,518	..	..	1. Wheat.
2. Atta, etc. † ..	39,769	..	37,120	194,313	..	191,664	212,822	..	210,173	209,975	2,649	207,326	244,759	7,002	237,757	51,953	..	..	2. Atta, etc. †
3. Rice ..	359,180	..	356,351	409,239	..	406,404	309,563	..	306,728	301,962	2,835	299,127	402,610	4,529	398,081	196,666	..	..	3. Rice.
4. Paddy †, etc. ..	66,590	..	64,947	60,941	..	59,298	76,418	..	74,775	79,606	1,643	77,963	112,057	1,010	111,047	91,937	..	..	4. Paddy †, etc.
CEREALS B † ..	690,088	..	629,367	734,322	..	673,601	798,729	..	738,008	799,195	§445,958	353,237	1,059,389	772,487§	287,402	760,298	..	..	CEREALS B †
5. Millets and pulses.																			5. Millets and pulses.
6. Vegetables ..	903,728	..	903,728	869,635	..	869,635	981,431	..	981,431	982,019	..	982,019	1,134,487	..	1,134,487	674,176	..	..	6. Vegetables.
7. Oils †, etc. ..	17,843	..	17,843	18,218	..	18,218	19,210	..	19,210	25,136	..	25,136	28,949	..	28,949	17,054	..	..	7. Oils †, etc.
8. Oil-seeds ..	38,957	..	38,957	46,843	..	46,843	56,546	..	56,546	79,855	..	79,855	118,678	..	118,678	85,590	..	..	8. Oil-seeds.
9. Ghee †, etc. ..	101,663	..	101,663	89,425	..	89,425	98,874	..	98,874	80,559	..	80,559	85,147	..	85,147	51,261	..	..	9. Ghee †, etc.
10. Gur † ..	128,548	..	128,548	139,722	..	139,722	243,520	..	243,520	382,005	..	382,005	309,971	..	309,971	374,491	..	..	10. Gur †.
11. Sugar ..	157,707	..	155,956	87,552	..	85,801	93,802	..	92,051	103,013	1,751	101,262	141,617	11,282	130,335	116,940	..	..	11. Sugar.

(27-28)

*Figure for imports, vide Municipal Records, include imports both by road as well as railways.

†Figures for exports in 1941-42 to 1943-44 are vide Railway records. Corresponding figures for 1938-39 to 1940-41 are not available. Export figures for 1941-42 have been provisionally adopted for the earlier years too. Export figures by road are not available from Municipal records. Export of food articles by road, however, is not prominent in the case of Lucknow City.

‡In import figures, (1) "Atta, etc." includes *sujji*, *aida*, *rava* and gram *atta* also. (2) "Paddy, etc." includes *dhan* as well as *munji*. (3) "CEREALS B" include *juar*, *bajra*, gram and pulses. Separate figures for each are not available. (4) "Oils, etc." includes mustard oil and all other oils. (5) "Ghee etc." includes animal ghee as well as artificial ghee. (6) "Gur" includes all forms of raw Sugar like *gur*, *rab*, *shakkar*, *nijha*.

§Export figures for CEREALS B in 1941-42 and 1942-43 also include 385,237 maunds of gram in 1941-42 and 602,215 maunds of gram in 1942-43 that were exported, on Government account, to other parts of India. Since however, gram was not usually exported from Lucknow in such large quantities in the earlier years, necessary deduction has been made from the total export figure for Cereals B in 1941-42, while adopting it for the preceding years, vide † above.

||Complete figures for 1943-44 could not be obtained in time. Figures for imports refer to the period April, 1943 to December 31, 1943, that is, for 9 months only.

The above figures are the annual averages for the respective seasons of different fruits.

APPENDIX II

Fluctuations in the population and the supply of important food articles in Lucknow City (1: 38-39 to date)

Years	Population	Adult value	Index of population, 1939=100	Corresponding index numbers of food-supply (1938-39=100)											Years	
				Wheat and ata, etc.	Rice and paddy, etc.	Cereals A [(5)+(6)]	Cereals B	All cereals [(7) × (8)]	Veg- tablets	Oils, etc.	Oil-seeds	Ghee, etc.	Gur, etc.	Sugar, etc.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1931	274,659	233,460	..	..	..	..	..	..	..	..	..	..	..	..	..
1939	361,480	307,258	100	100	100	100	100	100	100	100	100	100	100	100	100	1938-39
1940	374,328	318,178	103.5	106.2	110.5	107.4	107.0	103.5	96.2	102.1	120.2	88.6	108.7	56.1	1939-40	
1941	387,177	329,100	107.1	107.1	90.6	102.5	117.3	103.0	168.6	107.7	146.1	97.3	189.4	59.0	1940-41	
1942	420,874	357,743	116.4	108.6	89.5	103.3	56.1	86.2	108.7	140.9	205.0	79.2	297.2	65.0	1941-42	
1943 (actual) ..	454,571	386,385	125.7	101.2	120.8	106.7	45.7	85.5	125.5	162.2	304.6	83.6	241.1	82.6	1942-43	
1943 (rationed) ..	299,871	249,892	..	..	..	..	..	..	..	..	..	..	..	..	..
1944 (actual) ..	430,709	366,103	119.2	..	..	..	..	..	..	..	..	..	..	..	..
1944 (rationed) ..	349,356	291,130	..	..	..	..	..	..	..	..	..	..	..	..	1943-44

Notes—(1) In calculating adult values, each child (0—15 years) has been taken to be equal to half the adult (15 years and over).

(2) It has been assumed that the constitution of the population according to relevant age groups remained the same as in 1931 (about 30 per cent. children and 70 per cent. adults).

(3) Population for 1939 and 1940 have been interpolated between the census figures for 1931 and 1941. Population for 1942 has been interpolated between the census figure for 1941 and the population in 1943 as determined by the Civil Defence Department (now Rationing Department) of the United Provinces Government through an actual rationing census.

(4) Rationed populations for 1943 (as on December 31, 1943) and for 1944 (as on June 1, 1944) indicate those parts of the population of Lucknow which had been actually covered by ration cards up to the dates noted above. Ratio between adults and children is 2:1. More ration cards are being distributed every week.

(5) Rationed population as on June 9, 1944, constitutes 81.1 per cent. of the corresponding total population, while that on December 31, 1943, constituted only 66 per cent. of the corresponding total population.

(6) Rationed population for 1943 included 248,838 (82.98 per cent.) public; 13,727 (4.58 per cent.) factory workers and 37,306 (12.44 per cent.) railway employees. Corresponding figures for 1944 are: 275,915 (78.93 per cent.) public; 22,258 (6.38 per cent.) factory workers and 51,153 (14.64 per cent.) railways employees.

(7) The population of Lucknow according to the rationing census held on June 1, 1944, indicates a decline below the corresponding population on December 31, 1943. A possible explanation for this may be that the census for 1944 was held in the month of June, whereas the census for 1943 was held in December. It is an established fact at Lucknow that many upper-class people migrate to the hills in summer and quite a large number of people from among the lower classes, particularly labourers, move down to the villages on account of the harvesting season. Apart from this, Lucknow is an important centre of education. The students belonging to the mofussil areas go back to their native towns and villages. The decline in population may, therefore, be attributed to all these causes. It is interesting to note further that the population on September 1, 1944 has been estimated at 444,225. These figures are revised every week by the Rationing Department of the United Provinces Government.

The above figures are the annual averages for the respective seasons of different fruits.

APPENDIX III

Note on the Imports and Exports of Fruits, Eggs, Poultry, Fishes and Meat at Lucknow (pre-war and present)

(By MR. JOHN A. MANAWWAR, Provincial Marketing Officer, United Provinces, Lucknow)

THE town of Lucknow is a large consuming centre with a total population of approximately over 4 lakhs at present. Its requirements for the main articles of food are not met by local produce, that is, by the produce of the surrounding area brought to the town by road. Consequently, the supplies have to be drawn by rail from great distances to supplement the local arrivals. In the present note special stress is laid on the effect of war on the supplies of certain articles of food and their prices. The figures collected and given here-under are only the estimated average arrivals for a year.

I—Fruits

Name of fruit	Present supplies		Pre-war supplies		Sources of imports
	Quantity	Value	Quantity	Value	
	Mds.	Rs.	Mds.	Rs.	
Loquat ..	300	3,000	450	2,250	Saharanpur and local.
Guavas ..	2,000	10,000	4,000	5,000	Gorakhpur and Allahabad.
Pomegranate ..	900	45,000	1,900	45,000	Ahmedabad and Chaman.
Grapes ..	700	80,000	1,800	54,000	Nasik and Chaman.
Plums ..	400	5,000	300	2,400	Naini Tal.
Mangoes ..	20,000	4,00,000	29,000	2,90,000	Local and Muzaffarnagar.
Bananas ..	9,600	1,54,000	18,000	1,08,000	Hajipur.
Apricot ..	300	2,400	700	2,800	Naini Tal.
Lichi ..	6,000	1,20,000	15,000	1,35,000	Muzaffarpur.
Oranges ..	3,600	40,800	15,750	23,650	Poona and Nagpur.
Papaya ..	400	5,000	350	2,750	Local.
Apples ..	300	18,000	600	18,000	Kashmir and Kumaun.
Pears ..	300	10,000	500	3,500	Peshawar and Naini Tal.
Peaches ..	250	9,000	400	6,000	Naini Tal and Peshawar.
Sweet lime ..	1,500	10,500	2,000	8,000	Kaimganj and local.
Melons ..	10,000	1,50,000	15,000	75,000	Local and Farrukhabad.

The above figures are the annual averages for the respective seasons of different fruits.

During the pre-war days the demand for fruits was easily met, but this is not so now because the supplies are very much reduced on account of transport difficulties and direct military purchases in areas of production. The mangoes and papayas are produced locally and, therefore, their supplies have slightly increased owing to the high prices available now. The rest of the fruits are imported by rail and their supplies have gone down.

Price Statement

Name of fruit	Price	
	Present	Pre-war
Loquat	Re. 0-6 to Re. 0-8 per seer ..	Re. 0-2 to Re. 0-3 per seer.
Guavas	Re. 0-2 to Re. 0-5 per seer ..	Re. 0-0-6 to Re. 0-1 per seer.
Pomegranate	Re. 1-4 to Rs. 2 per seer. ..	Re. 0-12 to Re. 0-14 per seer.
Grapes	Rs. 2 to Rs. 4 per seer ..	Re. 0-8 to Re. 0-12 per seer.
Plums	Re. 0-5 to Re. 0-7 per seer ..	Re. 0-3 to Re. 0-4 per seer.
Mangoes	Re. 1 to Rs. 6 per <i>dheri</i> ..	Re. 0-8 to Rs. 3 per <i>dheri</i> .
Bananas	Re. 0-4 to Re. 0-6 per dozen	Re. 0-1 to Re. 0-1-6 per dozen.
Lichi	Re. 0-8 to Re. 0-12 per seer..	Re. 0-3 to Re. 0-4 per seer.
Oranges	Re. 1 to Rs. 1-12 per dozen..	Re. 0-8 to Re. 0-12 per dozen.
Apricots	Re. 0-6 to Re. 0-12 per seer..	Re. 0-3 to Re. 0-4 per seer.
Papaya	Re. 0-6 to Re. 1 per seer ..	Re. 0-1-6 to Re. 0-2 per seer.
Apples	Re. 1 to Rs. 2 per seer ..	Re. 0-8 to Re. 1 per seer.
Pears	Re. 0-12 to Re. 0-13 per seer	Re. 0-2-6 to Re. 0-3 per seer.
Peaches	Re. 0-14 to Re. 1 per seer ..	Re. 0-5 to Re. 0-6 per seer.
Sweet lime	Re. 0-2 to Re. 0-3 per seer ..	Re. 0-1 to Re. 0-1-6 per seer.
Melons	Re. 0-6 to Re. 0-8 per seer ..	Re. 0-2 to Re. 0-3 per seer.

It will be observed from the above statement that there is a great variation in the prices of each fruit during the present year, whereas in the pre-war days there was no such variation.

The *beoparies* import fruits in large quantities from outside markets and auction them to the dealers through commission agents in smaller lots. The public buy fruits from these retailers.

The present difficulty in getting the supplies of fruits can be redressed to some extent, if better transport facilities are made available.

II—Eggs

The demand for eggs has much increased at present mainly due to the arrival of a large number of troops, evacuees and refugees to the town and to the inclusion of eggs in the ration of certain troops and also to the fact that the majority of the military people is regular egg-consumer. The

following statement shows the position of demand and supply both at present and in the pre-war days :

—	Total demands	Local production and arrivals by road	Arrivals by rail supply	Total	Deficit	Sources of arrivals
Pre-war ..	150,000	87,000	60,000	147,000	3,000	Bara Banki, Sultanpur, Par-tabgarh and Bahraich.
Present ..	300,000	120,000	120,000	240,000	60,000	Sitapur, Gonda, Hardoi and Bengal.

It will be observed from the above table that the deficit was only a nominal one in the pre-war days, whereas it has increased very considerably at present.

The egg collectors go from village to village, buy eggs from the producers and sell their entire collection to the assembling merchants, who in their turn bring the same to the town by road or rail according to the distance. The egg merchants in the town buy eggs from them and sell them to the consumers in retail.

The price of eggs has gone very high at present as is shown by the following statement :

—	Producer's price per dozen	Wholesale market price per 100	Retail market price per dozen
		Rs. a. p.	Rs. a. p.
Pre-war ..	Re. 0-5 to Re. 0-6 ..	3 8 0	0 9 0
Present ..	Re. 0-12 to Re. 0-14 ..	10 8 0	1 8 0

There is a great shortage of eggs at present with the result that both the military and the civil consumers are finding it exceedingly difficult to get eggs in the required quantities. Moreover recently the price has gone so high that quite a large number of people are not in a position to afford the regular consumption of eggs. The chief causes of the decrease in supply are the reduced production, transport difficulties, the shortage of small coins, development of new consuming centres, etc.

Of late, considerable quantities of eggs and fowls are being exported from Lucknow to Jhansi, Cawnpore, etc., on account of the prevalence of higher prices there. The result of this has been that part of the local demand remains unsatisfied. It should also be noted that the potential demand of the town is much greater than what is given here. If the prices go down, a large quantity of eggs will be required to meet the demand. The high prices have compelled many people to go without eggs.

An immediate development of the production of eggs is the only proper solution. Attracted by the high price and compelled by the urgency of their financial requirements many egg-producers are now selling away even their laying birds and if immediate steps are not taken to augment the production to enable it to cope with the increased demand, the province may soon be faced with a total depletion.

III—Poultry

What has been said about the eggs above applied exactly to the poultry as well. The position of demand and supply and the prices of fowls are shown by the following statements:

—	Demand	Local produce and arrivals by road	Arrivals by rail	Total supply	Deficit	Sources of arrivals
Pre-war ..	30,000	24,500	5,000	29,500	500	Bara Banki and Partabgarh.
Present ..	45,000	10,400	10,900	21,300	23,700	Shahjahanpur.

Price Statement

—	Producer's price per fowl	Wholesale price per score	Retail price per fowl
Pre-war	Re. 0-10	Rs. 17-8	Re. 1-1
Present	Rs. 2 to Rs. 2-2	Rs. 45	Rs. 2-8 to Rs. 2-12

IV—Fishes

The production of fishes in Lucknow or near about is only small and the major part of the supply has to be imported from other places in the Province. The present requirements of the town are met only in part, and therefore both military and the civil consumers are finding it exceedingly difficult to obtain good and fresh fish in the required quantities. It is very difficult to estimate the demand with any degree of exactitude. The lower the price, the higher the demand and vice versa.

The demand is capable of a very large expansion and a considerable part of it remains unsatisfied at present. The pre-war and present supply of fishes is shown below :

Supply						Mds.
Pre-war	..	..	..	..	..	3,500
Present	..	..	..	..	..	4,500

Price Statement					
—			Small fishes such as <i>chilwas</i> , etc.	Bigger fishes such as <i>Rohu</i> and <i>parhan</i>	
Pre-war	..	..	Re. 0-3 to Re. 0-4 per seer	Re. 0-5 to Re. 0-6 per seer.	
Present	..	..	Re. 0-8 to Re. 0-12 per seer	Re. 1-4 to Re. 1-8 per seer.	

V—Meat

Like the other commodities there is a general shortage of meat as well and the requirements of the town are not easily met. The pre-war and the present supply of meat for the town is shown below :

					Beef	Mutton
					Mds.	Mds.
Pre-war	..	..	..	..	10,500	2,500
Present	..	..	..	..	15,500	3,500

It will be observed from the above figures that the supply has much increased. Yet it remains considerably short of that of the present demand which has greatly increased on account of increased military and civil population. The price of meat has also gone very high at present as is evident from the following figures :

					Beef	Mutton
Pre-war	..	..	..	..	Re. 0.3 to Re. 0.4 per seer	Re. 0.6 to Re. 0.8 per seer.
Present	..	..	..	..	Re. 0.6 to Re. 0.7 per seer	Re. 0.12 to Re. 1 per seer.

APPENDIX IV

Note on the supply of salt at Lucknow

Early in 1942 complaints about the high prices and shortage of salt in districts began to be received. The then existing system of distribution of salt was rather chaotic. Registered salt traders used to indent for supplies of salt at various sources and the indents were cleared by a system of lottery. The middlemen then used to sell wagons of salt to traders from different provinces at exorbitant premia. As much as Rs. 800 per wagon profit was charged by Sambhar salt traders from traders in this Province. On representations made to the Government of India in October, 1942, the Government of India issued a Salt Emergency Distribution Order and directed that 50 per cent. of the total daily clearances were to be sent to nominees of District Magistrates direct and the remaining 50 per cent. through traders at source, whose profit was limited to Rs. 50 per wagon. The number of wagons for each district in the Province was also fixed on a *per capita* consumption of 6 seers per head per annum on the population of 1941 census. The Provincial Government simultaneously licensed dealers in salt and prohibited the transfer of salt from any district without the permission of the District Magistrate. Although 50 per cent. of the salt requirements of a district were received regularly under this system, the traders at source still found means to evade the limit of Rs. 50 imposed on the profit they could make on the balance. On further representations by this Government the Government of India ordered that all the wagons allotted to a district were to be supplied direct to the District Magistrate's nominees every month. The result is that salt is now available in all districts at reasonable prices in adequate quantities. From time to time additional wagons are sent to districts to build up a reserve and most districts have now built up one month's reserve to provide against any emergency due to breakdown in transport.

Indices of the monthly retail prices of

Commodities		Wheat				
Years	Months ending	1941	1942	1943	1944	1941
		1941	1942	1943	1944	1941	1942
January 31	..	124	172	303	396	118
February 28/29	..	112	198	303	396	118
March 31	..	114	166	343	468	127
April 30	..	103	166	332	396	132
May 31	..	113	187	447	388	134
June 30	..	132	214	468	396	142
July 31	..	149	234	400	396	148
August 31	..	147	234	479	..	142
September 30	..	156	245	468	..	142
October 31	..	156	257	468	..	142
November 30	..	191	322	429	1,940	154
December 31	..	191	322	396	126	148

Indices of the monthly wholesale prices of sor-

Commodities	Wheat						Rice					
	1939	1940	1941	1942	1943	1944	1939	1940	1941	1942	1943	
January ..	..	141	125	173	208	397	..	104	117	145	250
February ..	..	141	118	198	298	397	..	104	104	150	250
March ..	..	141	114	170	346	466	..	104	125	156	289
April ..	..	134	108	170	335	390	..	117	118	156	341
May ..	..	122	114	198	447	373	..	117	132	167	441
June ..	..	121	132	215	466	397	..	117	141	203	441
July ..	100	126	149	233	488	397	100	117	148	218	458	
August ..	105	134	151	233	477	..	99	117	144	218	442	
September ..	115	131	160	235	466	..	100	95	143	234	384	
October ..	115	122	158	258	466	..	99	121	143	220	388	
November ..	149	128	193	315	436	..	111	121	150	250	352	
December ..	140	126	192	315	402	..	94	119	147	250	352	

APPENDIX V

the important food article at Lucknow from July, 1939 to July, 1944. [B

1944	Dal Arhar						Sugar					
	1939	1940	1941	1942	1943	1944	1939	1940	1941	1942	1943	1944
341	..	106	77	113	240	300	..	112	87	110	140	140
390	..	113	..	116	240	313	..	114	83	111	140	140
441	..	100	68	116	240	328	..	110	87	116	140	140
441	..	95	69	150	249	307	..	114	87	116	140	140
428	..	86	69	139	288	253	..	113	87	124	140	140
434	..	90	82	171	313	267	..	110	87	126	140	140
434	100	82	87	190	313	258	100	92	93	119	140	140
..	100	90	86	180	328	..	98	82	93	121	140	..
..	100	89	86	200	343	..	103	82	93	121	141	..
..	103	84	86	212	344	..	111	86	92	119	142	..
..	113	84	118	249	338	..	137	86	105	119	155	..
..	100	81	116	265	293	..	119	85	108	119	146	..

APPENDIX VI

Indices of the monthly retail prices of some important food articles in Lucknow City from December, 1940 to July, 1944.

Base, July 31, 1939=100

Commodities	Wheat			Rice			Dal arhar			Dal urd			Sugar			Commodities					
	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending							
January 31	124	172	303	396	118	148	254	398	88	106	229	292	100	146	179	229	75	100	130	135	January.
February 28/29	112	198	303	396	118	154	254	395	75	108	238	292	100	146	183	221	75	105	130	135	February.
March 31	114	166	343	468	127	161	296	444	75	108	229	304	100	142	208	246	75	110	130	135	March.
April 30	103	166	352	396	132	161	355	444	75	113	229	292	113	142	229	246	75	110	130	135	April.
May 31	113	187	447	398	134	169	444	444	88	129	267	246	138	146	246	246	85	110	130	135	May.
June 30	132	214	468	396	142	209	444	444	88	158	292	254	150	154	254	246	80	110	130	135	June.
July 31	149	234	490	396	148	215	474	444	100	178	292	246	150	167	267	246	90	120	130	135	July.
August 31	147	234	479	..	142	215	444	..	100	167	304	..	150	166	304	..	90	110	130	..	August.
September 30	156	245	468	..	142	222	395	..	100	179	321	..	163	179	292	..	85	110	130	..	September.
October 31	156	257	468	..	142	222	395	..	80	200	321	..	145	179	292	..	90	110	130	..	October.
November 30	191	322	429	1,940	154	254	355	1,940	100	229	321	1,940	152	188	292	1,940	100	160	135	1,940	November.
December 31	191	322	396	126	148	254	323	120	110	246	321	88	149	183	229	100	100	110	135	75	December.

base. July, 1939=100.]

Commodity	Year	Gur						Commodities
		1939	1940	1941	1942	1943	1944	
Months								Months.
January	7	..	62	25	49	81	70	January.
February	7	..	58	21	62	81	70	February.
March ..	7	..	58	26	70	108	72	March.
April	8	..	58	25	70	117	78	April.
May ..	8	..	62	24	76	113	82	May.
June ..	8	..	48	27	110	95	88	June.
July ..	7	100	59	45	127	110	102	July.
August		95	66	44	131	111	..	August.
September		100	58	44	131	120	..	September.
October		111	48	47	155	120	..	October.
November		92	42	55	110	131	..	November.
December		66	29	54	107	79	..	December.

(88-48)

Indices of the monthly retail prices of .

Commodities	Wheat			
	1941	1942	1943	1944
Years				
Months ending				
January 31	124	172	303	396
February 28/29	112	198	303	396
March 31	114	165	343	468
April 30	103	166	332	396
May 31	113	187	447	368
June 30	132	214	408	396
July 31	149	234	490	396
August 31	147	234	479	..
September 30	156	245	468	..
October 31	156	257	468	..
November 30	191	322	429	1,940
December 31	191	322	396	126

APPENDIX VI

Indices of the monthly retail prices of some important food articles in Lucknow City from December, 1940 to July, 1944.

Base, July 31, 1939=100

Commodities	Wheat			Rice			Dal arhar			Dal arul			Sugar			Commodities					
	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending	Years	Months ending							
January 31	1941	172	1944	396	118	148	254	338	88	106	229	292	100	146	179	229	75	100	130	135	January.
February 28/29	1941	198	1944	396	118	154	254	395	75	108	238	292	100	146	183	221	75	105	130	135	February.
March 31	1941	166	1944	468	127	161	296	444	75	108	229	304	100	142	208	246	75	110	130	135	March.
April 30	1941	166	1944	396	132	161	355	444	75	113	229	292	113	142	229	246	75	110	130	135	April.
May 31	1941	187	1944	368	134	169	444	444	88	129	267	246	138	146	246	246	85	110	130	135	May.
June 30	1941	214	1944	396	142	209	444	444	88	158	292	254	150	154	254	246	80	110	130	135	June.
July 31	1941	234	1944	396	148	215	474	444	100	178	292	246	150	167	267	246	90	120	130	135	July.
August 31	1941	234	1944	479	142	215	444	..	100	167	304	..	150	166	304	..	90	110	130	..	August.
September 30	1941	245	1944	468	142	222	395	..	100	179	321	..	163	179	292	..	85	110	130	..	September.
October 31	1941	257	1944	468	142	222	395	..	80	200	321	..	145	179	292	..	90	110	130	..	October.
November 30	1941	322	1944	429	154	254	355	1,940	100	229	321	1,940	152	188	292	1,940	100	100	135	1,940	November.
December 31	1941	322	1944	396	148	254	323	120	110	246	321	88	149	183	229	100	100	110	135	75	December.

APPENDIX VII

The monthly working class cost of living index numbers at *Caumppore*, August, 1939 to July, 1944
(Base : August, 1939=100)

Group-head	Index for food (42)*					Index † for non-food (27)*					General cost of Living index (59)*					Group-head			
	Years		Months			Years		Months			Years		Months						
	1939	1940	1941	1942	1943	1944	1939	1940	1941	1942	1943	1944	1939	1940	1941	1942	1943	1944	January.
	..	115	111	143.8	211.2	321.1	..	112.5	108.4	146.3	247.2	278.2	..	114	110	144.8	225.3	304.3	February.
	..	111	108	143.7	213.0	308.9	..	113.5	108	145.2	266.7	280.8	..	112	108	144.3	234.0	297.9	March.
	..	108	104	151.6	214.8	299.7	..	110.5	109	146.2	295.0	285.1	..	109	106	149.5	246.2	294.0	April.
	..	111	105	148.3	246.8	336.8	..	108.4	110	151.1	301.7	284.2	..	110	107	149.4	268.3	316.2	May.
	..	109	105	153.4	280.0	328.1	..	109	112.7	158.5	313.8	295.4	..	109	108	155.4	298.7	315.3	June.
	..	109	114	175.9	353.7	324.7	..	108	114	174.4	308.0	300.2	..	108	114	175.3	335.8	315.1	July.
	..	109	125	189.9	376.0	344.8	..	109	127.5	191.9	285.8	299.1	..	109	126	190.7	340.7	326.9	August.
	100	114	127.8	206.8	380.1	..	100	109	134.4	196.1	274.8	..	100	112	130.4	202.6	338.9	..	September.
	106	115	132.9	208.1	393.0	..	103.4	109.9	132.6	191.7	291.5	..	105	113	132.8	201.7	353.3	..	October.
	105	115	133.3	202.1	390.1	..	105	107.3	134.6	211.6	283.8	..	105	112	133.8	205.8	348.5	..	November.
	105	115	145.4	217.5	367.0	..	105	107.3	139.5	233.6	282.4	..	105	112	143.1	223.8	333.9	..	December.
	114	113	150.2	212.6	332.8	..	109	108	152.8	241.7	283.7	..	112	111	151.2	224.0	313.6	..	

* Indicates weight assigned to the group-head concerned.

† Includes fuel and light, clothing, house rent, and miscellaneous groups.

APPENDIX VIII

Fortnightly Cost of Living Indices of low paid Government employees at Lucknow, January, 1941 to July, 1944.
(Base, July 31, 1939=100)

Group-heads Years	Food group (78)*			Non-food Group (22)*			Cost of Living Indices (100)*					
	1941	1942	1943	1944	1941	1942	1943	1944	1941	1942	1943	1944
January 15	108	137	226	302	116	157	279	348	110	141	238	312
" 31	104	135	228	304	110	161	293	344	106	141	242	313
February 15	106	145	227	318	114	161	302	351	108	149	243	305
28/29..	104	148	231	308	115	164	349	332	106	151	257	326
March 15	110	137	255	352	120	164	349	332	112	143	275	314
" 31	118	140	284	363	136	163	344	332	122	145	297	348
April 15	127	138	272	336	154	167	356	332	133	144	291	355
" 30	125	143	304	326	137	167	356	332	128	148	321	330
May 15	125	151	336	325	137	173	380	343	128	156	345	329
" 31	127	169	337	327	143	200	378	343	122	176	341	340
June 15	127	174	345	331	136	216	335	390	133	183	345	349
" 30	125	178	368	327	154	209	335	413	133	185	361	342
July 15	125	185	356	327	137	225	343	394	128	192	353	342
" 31	125	182	346	..	137	205	360	..	128	187	355	..
August 15	125	182	346	..	137	205	360	..	128	187	349	..
" 31	125	185	340	..	137	215	376	..	128	192	348	..
September 15	128	190	337	..	143	215	376	..	132	195	346	..
" 30	127	186	337	..	150	222	376	..	132	194	345	..
October 15	126	199	341	..	148	240	376	..	131	208	349	..
" 31	131	206	333	..	160	245	376	..	137	215	342	..
November 15	142	230	321	..	166	244	376	..	147	233	333	..
" 30	145	235	320	..	170	254	376	..	151	239	332	..
December 15	143	234	301	..	174	257	348	..	149	239	312	..
" 31	..	..	..	..	..	..	..	..	..	..	..	..

* Figures indicate weight ts assigned to each group.

APPENDIX X

Index numbers of the wholesale prices of agricultural products and the retail prices of non-agricultural goods at Carnapore, of their purity and of the corresponding currency expansion, in India, from April, 1938 to date. (Base : Average of September, 1938 to August, 1939—100)

Month	Index of agricultural wholesale prices	Index of non-agricultural retail prices	Column 2 as percentage of column 3	Index of currency expansion	Remarks	
1	2	3	4	5	6	
1938						
April	94	97	97	97	Column 4 indicates the index numbers of agricultural products, if the corresponding index numbers of non-agricultural goods are assumed to be uniformly 100.	
May	93	92	101	95		
June	97	98	99	94		
July	99	93	100	94		
August	99	..	..	95
September	95	..	..	96
October	97	..	..	97
November	95	92	103	98		
December	95	95	100	100		
1939						
January	100	96	104	102		
February	102	95	107	103		
March	99	..	..	103
April	99	104	95	102		
May	100	106	94	100		
June	101	99	102	100		
July	105	101	104	99		
August	107	102	105	100		
September	110	106	104	107		
October	105	107	98	111		
November	117	112	104	114		
December	115	117	98	116		
1940						
January	113	117	97	118		
February	110	116	95	118		
March	109	118	92	117		
April	110	114	96	116		

APPENDIX X—(continued)

Months	Index of agricultural wholesale prices	Index of non-agricultural retail prices	Column 2 as percentage of column 3	Index of currency expansion	Remarks
1	2	3	4	5	6
May	112	117	96	110	Column 4 indicates the index numbers of agricultural products, if the corresponding index numbers of non-agricultural goods are assumed to be uniformly 100.
June	105	112	94	113	
July	108	118	92	108	
August	111	117	95	106	
September	111	116	96	104	
October	109	115	95	103	
November	103	112	92	102	
December	98	115	85	105	
1941					
January	91	116	78	108	
February	90	118	76	111	
March	85	119	71	113	
April	87	121	72	119	
May	83	121	70	121	
June	94	126	75	123	
July	110	131	84	123	
August	112	127	83	123	
September	114	129	88	127	
October	111	128	87	130	
November	122	140	87	134	
December	124	153	81	141	
1942					
January	125	144	87	150	
February	132	144	92	158	
March	129	147	88	169	
April	123	152	81	180	
May	147	161	91	190	
June	167	177	94	183	
July	190	183	104	188	

APPENDIX X—(concluded)

Months	Index of agricultural wholesale prices	Index of non-agricultural retail prices	Column 2 as percentage of column 3	Index of currency expansion	Remarks
1	2	3	4	5	6
August	192	200	96	195	Column 4 indicates the index numbers of agricultural products, if the corresponding index numbers of non-agricultural goods are assumed to be uniformly 100.
September	188	201	94	202	
October	189	208	91	209	
November	173	221	78	217	
December	217	222	98	225	
1943					
January	217	236	92	236	
February	220	240	92	244	
March	220	267	82	255	
April	244	270	90	267	
May	271	292	93	279	
June	289	286	101	289	
July	312	273	114	295	
August	332	269	123	301	
September	325	284	114	304	
October	329	281	117	312	
November	299	280	107	318	
December	277	275	101	335	
1944					
January	267	279	96	341	
February	252	277	91	345	
March	254	280	91	351	
April	262	283	93	358	
May	247	284	87	362	
June	257	279	92	370	
July	265	280	95	367	

GOVERNMENT OF INDIA
DEPARTMENT OF FOOD



PRINCIPLES OF CEREAL
STORAGE

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PREFACE

The decision to prepare this little handbook was taken following a training course in the principles of grain storage given by the Food Department in November, 1944, at the Imperial Agricultural Research Institute to 95 officers from Provinces, States and Administrations from all over India. The Department of Food was asked to provide such a reference book, based on the lectures, for general guidance. Many independent requests had also been received for literature on this subject.

Although there exists a vast number of publications on various aspects of grain storage, there is lacking a concise guide covering the whole procedure of storage with reference to the conditions in India today. Individual contributions to the knowledge of grain storage, generally on specific problems, are scattered throughout a wide variety of scientific journals mostly inaccessible to the layman or the trader. On the other hand most general publications deal only with insect pests of grain and are more in the nature of reviews of the insects concerned and of the large number of control measures utilised throughout the world.

The two factors of paper limitations and of urgency of publication have necessitated considerable condensation of the original lectures but an effort has been made to discuss at some length these problems which experience has shown to cause most conflict of opinion. The detailed descriptions of insects have been reduced to a minimum because these are already available in Miscellaneous Bulletin No. 57 of the Imperial Council of Agricultural Research.

A book of this size, compiled at short notice, cannot pretend to embrace all the possible methods of control and this has not been attempted. Emphasis has been laid on elementary hygiene and frequent inspection of stocks coupled with a recognition of the defects of the stores which have had to be utilised for lack of other accommodation. Highly technical complicated procedures have been avoided as not generally applicable at present, but as progress is made and conditions improve it may be possible at a later date to widen the scope of activities of those inspecting officers who are responsible for maintaining stocks of grain in sound condition.

The Department of Food has formed a Directorate of Storage which will be staffed with technical officers specially trained to advise on specific problems. Their duties will include devising means of application of new and improved control measures, assisting in the development of these in the laboratory and in practice, collection and dissemination of information from Indian and foreign sources, and general co-ordination of activities throughout India in the interest of grain conservation.

I take this opportunity of acknowledging gratefully the assistance rendered by Sardar Mohan Singh, Assistant Director of Storage, Department of Food, in the preparation of both this manual and the training course on which it is based.

I would crave the indulgence of the specialist where I have deliberately sacrificed strict scientific accuracy for the sake of clarity and brevity—in the interests of the layman for whom this book is intended.

F. P. COYNE,

Director of Storage, Department of Food, Government of India.

November, 1944.

CHAPTER I

STATEMENT OF THE PROBLEM

It should not be necessary to emphasise the need for saving every seer of grain available in India today. Quite apart from the temporary difficulties occasioned by the war—great though these be—the production of food grain in India is far from sufficient to meet a demand that rises every year with the increasing population. Increased production, either by extending the area under cultivation or by promoting higher yields from existing areas involves a long term policy which cannot produce marked results quickly. Importation from overseas is also likely to be limited in the immediate post-war period. But can we not at least ensure that the grain which comes to us is reserved for human consumption and does not suffer from depredations due to rodents, insects or moisture damage? It may not be possible to achieve this immediately but many of the losses can be greatly minimised by simple measures and within a short time it should be possible to reduce these losses to a small fraction of their present extent.

Are these losses then so large? The figures are extremely difficult to obtain with any accuracy but a very conservative estimation made in the Reports on the Marketing of Wheat and of Rice in India showed that peace-time losses totalled over 600,000 tons annually for these two grains alone. I deliberately use the word "conservative" because the grain trade supplied the figures and the grain trade does not view the matter in the same way. There is no reason why they should! If a merchant stores 1,000 maunds of wheat in a pit in May and finds that when he opens the pit in November he has 1,010 maunds of sound wheat plus 20 maunds rendered unfit for consumption by moisture damage he has done very well commercially, because the price of wheat is higher than when he purchased at the harvest and he has more than he bought. To him there is a net gain of 10 maunds instead of a 20 maunds actual loss. Nevertheless 2 per cent. of his original holding is no longer available for human or possibly even animal food. That is a simple example. Insect and rodent damage can also be compensated by increased moisture content in the same way, so that the trade figures give an unduly optimistic picture from the point of view of food wastage.

I have no hesitation in stating that rodent damage alone probably accounts for a million tons of all food grains with similar amounts lost from insect and moisture damage. A figure of three million tons may seem astonishing but that is the order of magnitude of the annual losses in India with which we are concerned today. The Imperial Agricultural Research Institute has come to a similar conclusion quite independently, taking the losses at 5 per cent. of all food grains produced and arriving at about 3.3 million tons. It is not profitable to argue about the actual figures however, nor does space permit an essay on this subject. It suffices to agree that losses of anything like this order are deplorable and if action can be taken to reduce them appreciably a very great contribution to the food supply of India will have been achieved.

I have mentioned the three sources of loss—rodents, insects and moisture—and I propose to deal with these separately except in as much as insect damage and moisture content of cereals are closely related. I have, therefore, started by considering climate and moisture damage, then standard types of storage, grading of godowns, and general hygiene which is the most important factor in good conservation. Insect pests of grain are then reviewed briefly. Fumigation is discussed in considerable detail and a short chapter on other control methods follows. To avoid breach of continuity I have left the rodent problem to the last two chapters but it is necessary to read Chapter XIV on rat-proofing before considering standard storage. It is hoped that in this way a clear picture of the position and of the action required will be presented to those concerned with grain storage.

These observations refer mainly to present conditions where large stocks of grain are being held by Provincial and State Governments. They are not

directed at the cultivator or holder of small stocks but the principles apply equally well there, and there is no room for complacency at any stage until the general standard of conservation is improved, from the time the grain is harvested until it reaches the consumer. An important factor in achieving this end would be the introduction of all-India standards for quality, with inducement to the seller to offer grain free from dirt and other impurities, and not affected by insects. This is a question for the future, but it is of most material importance to storage. When the expected improvements in storage materialise the time will then be appropriate to deal with this other fundamental matter. Under present conditions it would be futile to attempt to operate any such standards, but preliminary consideration might now be given to this project because it will require some time to organise an equitable and mutually beneficial system.

CHAPTER II

EFFECT OF CLIMATIC CONDITIONS ON GRAIN

It is well known that stored grain is affected by climate and that, in the limiting case, it is easier to keep grain free from trouble during the winter in the Punjab than during the monsoon in Bengal. Both Temperature and Humidity are concerned.

Temperature

This is less important than humidity but the two extremes of temperature are both favourable for grain conservation. Very high temperatures are not conducive to rapid insect breeding if correlated with low humidity and it is a fact that temperatures exceeding 100°F are seldom accompanied by very high humidity. (If they were it would be highly dangerous to human life). With high temperatures and low humidities grain also tends to lose moisture and become less liable to damage either from "heating" or from insect attack.

With low temperatures say less than 55°F, insect life is slowed down greatly and development may cease altogether during what is known as a "dormant" period. Low temperatures will also naturally counteract any tendency to "heat".

In addition large diurnal variations are not appreciated by insects which thrive best at a steady temperature. Thus an area with a daily maximum of 90°F and a daily minimum of 60°F will be less favourable than one with a maximum of 80°F and a minimum of 70°F. This is the kind of difference that may exist between an inland and a coastal area but in practice the higher humidity at the coast is probably of more importance than the steady temperature because large bulks of grain will not vary in temperature range to anything like the same extent as the atmosphere.

Humidity

Although everybody knows what a humid atmosphere is like in comparison with a dry one some definition is needed here before the subject can be discussed. The standard used in measurement is Relative Humidity which is a measure at a given temperature of the degree of saturation of air with water vapour. At any given temperature the maximum amount of water vapour that can be held in the atmosphere is definitely fixed—this is the saturation limit, where the Relative Humidity is 100 per cent. Such air when cooled will deposit moisture (e.g., dew) until it attains the new saturation limit for the lower temperature. Similarly if this air is heated it will be able to take up more water vapour to reach the saturation point at 100 per cent. Relative Humidity for the higher temperature. If air at any temperature is not saturated with water vapour the Relative Humidity will be below 100 per cent.—say 70 per cent. or 40 per cent. etc. It is measured by the difference in temperature registered by two thermometers, the bulb of one being kept wet. At 100 per cent. Relative Humidity the thermometers will read the same but as the Relative Humidity decreases the difference in the two readings will increase owing to the cooling caused by

evaporation of water from the wet bulb. By reading from Relative Humidity tables one can get the applicable figure from the two temperatures recorded.

It will not usually be necessary to do this but some understanding of the meaning of Relative Humidity is essential. Records are made daily at a large number of stations throughout India and are available from the Meteorological Department, Government of India.

The importance of this lies in the fact that the *moisture content of grain varies with this Relative Humidity*. Thus if grain is taken from Amritsar to Calcutta in July one would expect an increase in moisture content. In the reverse journey there would be a loss in weight. It is not desirable to try to memorise a lot of figures but the following statement is important and easy to remember.

The moisture content of grain which is at equilibrium with air at 75°F and 75 per cent. R. H. is approximately 14 per cent.

The importance of this particular moisture content lies in its being the maximum permissible for long term storage. At higher moisture content grain will tend to become mouldy, to germinate, or to "heat". I have mentioned "heating" of grain several times and it must also be defined. Excessive moisture induces both increased respiration of grain and the development of certain bacteria which raise the temperature locally to a high degree and cause serious damage to grain. It is similar to the effect produced when wet grass cuttings or weeds are put in a manure heap and allowed to ferment. Recent work has also shown conclusively that grain below 14 per cent. moisture content can show "heating" due to insects whose activities produce moisture with the same result—a wet blackened mass of grain unfit for food and liable to taint the balance of the stock. Modern elevators are fitted with thermometers at various levels in the bin and on any sign of a local rise in temperature the whole contents are discharged and filled into another bin, the exposure and mixing sufficing to allay the damage temporarily until the grain is put into consumption.

Let us now consider what bearing all this has on grain in India. There is a lack of precise information on grain moisture contents to cover all the climatic conditions but some figures are available. Wheat for example is harvested at the hottest and driest time of year so it comes into store with a comparatively low moisture content of the order of 8-11 per cent. water. Incidentally below 8 per cent. moisture there is little risk of insect attack and, as the grain lies in the hot sun after harvesting and before threshing, any insect life is likely to be destroyed by this natural "sunning". This applies equally to other *rabi* crop grains and pulses.

If we could take such insect-free dry grain into stores which are rat-proof, insect-proof and moisture proof we could keep it for a period of years without trouble either in bulk or in bags. Today there are very few grain stores that meet these requirements. That some do exist proves that the answer as well as the problem is realised in some areas. The *rabi* crop comes into store just before the monsoon when the Relative Humidity rises rapidly and the grain absorbs a corresponding amount of moisture which may cause direct damage and which at best *makes the grain much more susceptible to insect attack*. This would not be so important if it were not for the presence of the major insect pests of grain in practically every store in every market—and on most of the transport (road or rail) available for carrying grain.

The *kharif* crops of paddy, jowar, bajra and maize are harvested after the monsoon and do not get the same thorough drying. Those that are harvested while the shade temperature is still high will not dry out so well as *rabi* crops because the humidity is high and those which are harvested later do not get sufficient heat for effective drying. As might be expected, therefore, with these crops there is more danger from "heating" than from insect attack as the lower temperature slows down insect development. That is a broad generalisation

and in coastal areas the difficulties will be accentuated for both *rabi* and *khari* crops.

To illustrate this point during the recent storage training course six 100 gm. lots of wheat were weighed out and placed in six desiccators above mixtures of sulphuric acid and water of known Relative Humidity. The wheat samples were weighed at intervals with the following results:—

TABLE 1

Approx. R. H. %	Original weight (gms.)	Weight after 10 days (gms.)	Weight after 20 days (gms.)	Gain or loss %
0	100	93.9	92.8	-7.2
20	100	94.9	94.0	-6.0
40	100	96.6	97.0	-4.0
60	100	98.3	98.0	-2.0
80	100	99.9	99.9	-0.1
100	100	105.8	107.9	+7.9

These results illustrate the effect of Relative Humidity on grain. It can be seen that the grain originally was in equilibrium with about 80 per cent. R. H. below which it lost weight and above which it gained weight. No attempt was made to ascertain the actual moisture content of the grain nor to check the temperatures as neither of these figures will be required in general practice. What happened in this demonstration is exactly what happens to grain during storage, but it will be a slower process with large amounts of grain.

Those concerned with grain storage are not required to measure moisture content of grain but they should be able to say from local meteorological conditions whether a claim for loss through "dry-age" is justified or not. Such claims may be made to cover other losses and in fact have been known to be made under conditions where the grain was bound to increase in weight from absorption of moisture, i.e., R. H. had been increasing during storage.

Grain will gain in weight during the monsoon and will lose in weight afterwards if the Relative Humidity is then low. On the seaboard such losses are not to be expected to the same extent as inland and should not generally be significant. The increase in weight of grain transferred from say Lyallpur to Karachi will be marked at any time of the year. In fact this is a recognised factor in the export trade from Karachi. The merchant knows that it is preferable to hold the grain at Karachi for some weeks or months before shipping rather than to rail from Punjab directly to steamer. Other factors, of course, have to be considered.

The experiment mentioned above is a simple one but a considerable amount of work has been done in U. S. A., U. K. and Australia on this subject. In a series of storage experiments in U. S. A. carried out in connection with germination tests at 70°F it was found that all samples of grain stored at or above 79 per cent. R. H. suffered mould damage within two months and that at 90 per cent. R. H. damage to grain occurred in less than one month. At low Relative Humidities (10 per cent. moisture content of grain) wheat, barley and oats were kept for over three years without harm (Robertson, Lute, Gardner. Journal of Agricultural Research, Volume 59, pages 281-291, 1939). The data tabulated below show the relationship between R. H. per cent. and moisture content of grain at 70°F as reported in this paper.

TABLE 2

Relative Humidity %	98	95	90	79	73.7	68.4	63	57.6
Moisture content of grain%	34	27	23	16	14	13	12	11

An Australian publication (Gay—Jour. Coun. Sci. Indust. Research, Volume 14, pages 117-120, 1941) gives an interesting comparison between hard wheat of high gluten content and soft wheat of low gluten content and demonstrates that both behave similarly, the difference in moisture content at any R. H. per cent. being practically negligible. The wheats used were Rancee 4H and Pusa 4. Hardness of wheat should not be confused with moisture content.

Let us now consider the meteorological data of India and find out if they can be of value in assessing the merits of different areas for storage of grain. The figures in Tables 3-6 are taken from the Govt. of India Meteorological Department compilation of 5 day averages over periods exceeding 25 years (up to 1931). It must be remembered that there may be big fluctuations from the average figure in any one year. For example Karachi shows an average of 7.5 inches of rain per annum while in 1944 the actual rainfall was over 30 inches. This is probably an extreme example but in the areas of heavy monsoon fluctuations are big, as every cultivator knows. The averages are, however, of considerable value provided this deviation is not forgotten.

Calcutta represents an inland area with a heavy monsoon.

Bombay represents a coastal area with a heavy monsoon.

Lahore represents an inland area with a light monsoon.

Karachi represents a coastal area with a light monsoon.

TABLE 3
CALCUTTA METEOROLOGICAL DATA

Month	Rainfall in inches	Mean Max. Temp. °F	Mean Min. Temp. °F	Relative Humidity % at	
				09:00 hrs. (I.S.T.)	18:00 hrs. (I.S.T.)
	0.34	78	55	84	51
January	1.32	83	61	83	48
February	1.44	91	69	78	45
March	1.89	95	76	75	51
April	5.75	95	77	77	68
May	11.90	91	79	83	78
June	12.51	89	79	86	82
July	12.69	88	78	86	81
August	9.87	88	78	86	79
September	4.19	87	75	83	74
October	0.66	82	65	78	64
November	0.12	77	55	80	58
December					
	62.68				

TABLE 4
BOMBAY METEOROLOGICAL DATA

Month	Rainfall in inches	Mean Max. Temp. °F	Mean Min. Temp. °F	Relative Humidity % at	
				09:00 hrs. (I.S.T.)	18:00 hrs. (I.S.T.)
	0.10	83	67	73	61
January	0.08	83	67	74	61
February	0.07	86	71	76	60
March	0.05	89	76	77	65
April	0.84	91	79	77	68
May	18.31	88	78	83	79
June	24.26	86	76	86	84
July	13.80	85	76	86	81
August	10.50	85	75	88	78
September	2.16	86	76	84	70
October	0.41	89	72	77	62
November	0.05	86	69	72	59
December					
	70.63				

TABLE 5
LAHORE METEOROLOGICAL DATA

Month	Rainfall in inches	Mean Max. Temp. °F	Mean Min. Temp. °F	Relative Humidity % at	
				09·00 hrs. (I.S.T.)	18·00 hrs. (I.S.T.)
January	1·05	69	41	86	42
February	0·94	73	45	77	45
March	0·86	83	54	64	29
April	0·54	97	65	47	20
May	0·70	104	73	41	18
June	1·68	107	80	51	33
July	5·48	101	81	69	48
August	5·33	98	79	75	47
September	2·36	98	74	68	38
October	0·25	95	61	61	33
November	0·07	83	48	70	40
December	0·36	73	41	86	45
	19·62				

TABLE 6
KARACHI METEOROLOGICAL DATA

Month	Rainfall in inches	Mean Max. Temp. °F	Mean Min. Temp. °F	Relative Humidity % at	
				09·00 hrs. (I.S.T.)	18·00 hrs. (I.S.T.)
January	0·52	76	58	64	45
February	0·39	77	61	72	54
March	0·33	82	69	80	60
April	0·17	85	73	87	75
May	0·07	89	79	88	75
June	0·86	91	83	86	75
July	2·94	89	81	88	76
August	1·67	85	78	90	77
September	0·42	85	77	88	75
October	0·01	82	73	81	71
November	0·04	86	66	87	65
December	0·14	78	60	64	47
	7·56				

The months which are not suitable for prolonged storage of grain are underlined and the most striking point is that Karachi is for six months of the year in spite of low rainfall not a good place to keep grain. This may surprise those who are aware of the importance of Karachi in peace time exports of grains and of the prevailing custom to store these before despatch. Generally, however, wheat moved into Karachi from May onward, and was practically all despatched by October. A comparatively short storage period of say 2 months is just enough to let it attain its maximum moisture content—more than counteracting any slight loss from insect damage which might occasionally take place. Conditions are greatly different today when grain is stored in Karachi throughout the year and for much longer periods. At no time of the year are conditions in Karachi adverse to insect development and increasing losses can be expected as a permanent grain insect population is built up.

Calcutta is an extremely bad place for grain storage during June/September and only in the first three months of the year can conditions be described

as good. Bombay is similar to Calcutta in the monsoon period but, being on the coast, it is during the winter much more favourable for insect development and, like Karachi, there is no period of the year adverse to insects. Lahore on the other hand shows no month really ideal for insect development. The very high temperatures of May/July are accompanied by low humidities and at no time does the Relative Humidity become excessive. There is, however, always some snag and here it is the *Khapra* beetle which is acclimatised to the Punjab conditions and can survive where other grain insects would do out.

The marked difference between maximum and minimum temperatures (diurnal variation) at Lahore in comparison with Karachi may also be noted. Calcutta also shows this difference, except during the monsoon.

What conclusions can be drawn from this survey? First, all coastal areas should be avoided for prolonged grain storage as far as practicable. Second, the wheat producing areas (as represented by Lahore) are the most suitable for grain storage and at the time of harvest wheat should be obtained in sound dry conditions. Third, transport should be reduced to a minimum during the monsoon period and areas of heavy rainfall should get stocks into store by June to carry them through this period.

There are other factors such as transport difficulties which make this ideal impossible at present but it should be borne in mind when planning ahead. This is of course, a matter of policy but the result of not being able to achieve what is technically desirable imposes a handicap on those who have to handle and store grain after it has been exposed to adverse weather conditions. Much can be done to minimise the losses which are inevitable where no precautions are taken.

CHAPTER III

MOISTURE AND INSECT DAMAGE TO CEREALS

Present storage conditions in India are fairly well known and need not be described. I. C. A. R. Bulletin No. 57 gives an excellent review of the many types of storage used by cultivators and villagers throughout India.

Because of the need for reserves being available in deficit areas large stocks of grain are held today in such temporary storage—good, indifferent, or bad—as could be rented or requisitioned by the authorities concerned. Heavy movements have been necessary in the monsoon period and bags of grain have lain for weeks on railway stations exposed to rain while awaiting transport. A gradual improvement is being effected and before the next monsoon break conditions should be very much better. It is likely, however, that moisture damaged grain will occasionally arrive at stores and I will now deal with this problem.

No bag of grain showing signs of wet or damp should be put into store. That is elementary, but if proper supervision is not available such bags will not be segregated. The grain will not be damaged if it is at once dried by spreading in the sun, or, in absence of sun by spreading out on a floor under cover. Alternatively wheat may be passed out at once for milling. Modern roller mills wash wheat before milling and a little damp grain can be utilised without trouble if it is in good condition otherwise.

It is common practice in the grain trade to "manipulate" damaged grain. This process is simply the mixing of small quantities of damp grain with larger amounts of dry grain so that the excess moisture is distributed evenly and the resultant moisture content is still below 14 per cent. A bag of grain averaging 18 per cent. moisture can be mixed with 7 bags of grain averaging 10 per cent. moisture to give 8 bags averaging 11 per cent. moisture. I do not suggest that merchants go to the trouble of ascertaining the water content of the grain. That is not necessary and from practical experience operators learn what is safe

and what is dangerous. There can be no objection to "manipulation" carried out by experienced staff on the above lines but it is open to two objections, viz. :—

(1) There is always the temptation to go just a little too far and to use an inadequate amount of dry grain or to mix inadequately. This saves trouble to the manipulator but may result in serious damage later if the grain is stored for any length of time. Today one has less advance information than in peace time regarding either destination or date of consumption of grain. Caution is, therefore, necessary and this operation of manipulation is one for experienced hands only.

(2) The other objection is a more serious one, the temptation to mix not only sound damp grain but damaged, mouldy or sprouted grain with good stock and even to do the same with weevilled grain, thus infesting the bulk of good grain. This may be done to avoid admitting damage through careless handling earlier, or in an attempt to pass the manipulated grain off as sound. In peace time the trade had normal methods of preventing such practice—the merchant who did this would lose his business to competitors. Today this kind of control does not exist. There is frequently no direct contact between supplier and ultimate buyer so the incentive is much greater.

My advice to grain storage officers is to be very wary of manipulation. Do not try it on your own responsibility and if it is done for you by experienced operators see that adequate supervision is provided.

Generally, however, grain will arrive without moisture damage and the principle of preventing it getting damp during storage is much easier to achieve than subsequent correction. If the bottom bags of a stack get damp one does not know until the stack is moved, when almost certainly the grain will be damaged. Direct contact with even concrete floors should, therefore, be avoided, and on no account should bags touch the walls. The walls of godowns are not moisture-proof and are not designed to take the enormous thrust of a stack of bags piled against them. Similarly in bulk storage one does not know if the pit used is damp until the grain is taken out. Experience has of course taught the trade which pits are reliable and which are not, but monsoon severity is a very variable factor.

Under normal conditions, however, some loss is expected in storage in underground pits. I am obliged to the U. P. Government for figures concerning 10 *khattis* used between May, 1943, and April, 1944, to hold wheat in Hapur.

TABLE 7

Weight of wheat loaded	8,162 maunds	100%
Weight of sound wheat removed	8,216 „	100.6%
Weight of damaged grain (<i>bhagar</i>)	197 „	2.4%

These figures illustrate admirably the difference between the outlook of the grain trade and of the Government. Commercially there is a slight gain in weight but from the point of view of food supplies nearly 200 maunds have been lost. I do not wish to suggest that better results could have been achieved by any other storage available at that time, but only to point out that where the question of new storage accommodation is being investigated the possibility of avoiding this loss should be considered seriously. By bulk storage in concrete *khattis* like those at Muzaffarnagar (U. P.) or in properly constructed brick bins such moisture damage can be entirely avoided. The economics of the Muzaffarnagar *khattis* are dealt with fully in the Report on the Marketing of Wheat in India (1937) which states that the extra cost of such storage was compensated by the absence of any taint on the grain and the **resulting higher price obtainable in the market.** It is clear, therefore, that even in peace-time trade the advantages of proper storage were realised in some areas. An extensive application of this knowledge is wanted today.

I have already pointed out that an increase in moisture content makes grain more susceptible to insect damage. Below 8 per cent. moisture little insect damage will occur but as the humidity increases with onset of the monsoon the moisture content of grain rises to 10 per cent., 12 per cent., 14 per cent. or even more. This can be prevented or at least greatly minimised by storing in properly constructed bins before the onset of the monsoon. All whole grains destined to be kept for use after the end of the monsoon would benefit from such storage. Ideally one would like to see the *rabi* crop which is destined for consumption in the last six months of the *rabi* crop year to be put into bulk storage before the middle of June in the producing area. The balance intended for consumption before and during the monsoon could be kept in bag storage without appreciable loss. Any insect attack in bulk storage can be readily detected and controlled by fumigation which is not readily applicable to godowns.

As for the *kharif* crop most of this will have gone into consumption before the monsoon breaks but stocks being held until November can also be stored in bulk. In areas with both crops it may be possible to use the same bins but generally this is not going to be practicable.

It may be added here that while the first of the paddy crop is frequently too damp for prolonged storage the remainder can be stored in bulk without difficulty. The question as to whether any particular consignment is suitable for bulk storage is a matter for local decision based on experience which should not be ignored.

Rice on the other hand is not generally considered in India as suitable for bulk storage because of liability to "heat". In Central Provinces, however, some areas regularly store rice in bulk for periods up to 5 months. Liability of rice to "heating" should be mainly a question of moisture content regarding which no data have been obtained so far. There may, however, be a complication in that the milling process transfers the causal organisms (bacteria) from the outside of the husk which is not a good medium for bacterial development to the starchy kernel which may be much more susceptible. This point requires detailed investigation. Rice, however, should be regarded as a milled product and not so suitable for prolonged storage as paddy. *Whenever possible paddy should be stored rather than rice.* It is realised that this is not possible in areas of normal rice deficit which have no milling plant.

Flour (*maida*) and *atta* are fully milled products and cannot be stored in bulk nor for prolonged periods. *Maida* can be kept for a maximum of six months without deterioration if free from insects. *Atta*, however, should not be stored for more than three months and in the hot weather a shorter storage period is advisable. Deterioration of *atta* apart from insect damage, is due to development of rancidity in the small amount of oil contained in the germ of the grain. Neither *maida* nor *atta* can be properly "reconditioned" by sieving or any other means once they have been heavily attacked by insects. Blending with fresh material is done but is of doubtful value except on the financial side which should be a secondary consideration in such matters. Disposal without delay as animal feeding stuffs is preferable.

With so much in favour of bulk storage it may be argued that where it is not available the best alternative is to pack a godown as solidly as possible with bags of grain, wall to wall and floor to roof in order to simulate bulk storage conditions either with or without linings of *bhusa*. If one could be sure that the grain was very dry, that it was originally free from insects, and that the store was also free from insects this may give good results. In absence of such conditions the risk taken by the procedure is very great, for if insects are present ideal conditions have been created for their rapid development.

It is not practicable to seal ordinary godowns so that the atmosphere inside will remain dry throughout the monsoon. There are innumerable cracks and crevices which cannot be sealed. In the monsoon the solid bulk of grain

bags will retain for a long time the heat of the previous dry weather. In practice what happens is that the humidity increases inside at a slower rate than outside but the temperature also falls more slowly. By the end of the monsoon the temperature inside is considerably higher than outside and the humidity much greater because it diminishes as slowly as it increased. If, therefore, any grain insects are present they will flourish exceedingly. Under such conditions one does not know what is happening in the middle of the stack and even if one did know, fumigation to destroy insects would not be feasible with such stacking.

For these reasons the accepted standards in the international grain trade are preferred—small stacks with the maximum possible amount of ventilation in the godowns. During heavy rain, of course, windows and doors should be closed but on dry days during the monsoon ventilation should be provided. Since remedial measures against insects are exceedingly difficult in godowns regular inspection at not more than monthly intervals is required. Any stack showing signs of insect damage should be allocated for immediate disposal independent of its normal order. In this way much damage and cross infestation of other stocks can be prevented.

The argument that insect attack generally begins on the outside of a stack does not affect the issue. If the grain was free of insects when stored the attack must come from the outside. If a hundred grain weevils assail a stack it makes no difference if two bags or two hundred bags are available—there is enough grain for them to start breeding freely.

CHAPTER IV

STANDARD BINS FOR BULK STORAGE

The difficulties of administrations in obtaining proper accommodation for grain stocks have necessitated resort to all kinds of unsuitable stores and to *ad hoc* arrangements of a temporary nature. There was neither time nor opportunity to study the question of storage as a long-term proposition, but improvement in the general condition of cereals and prevention of losses cannot be effected unless proper storage is available. Many Provinces and States are now considering the building of grain stores and enquiries have been received regarding the relative merits of bulk storage and bag storage. Wherever possible, bulk storage is preferable especially for wheat, gram, paddy and barley.

A) Advantage of bulk storage

- (1) Complete immunity from damage by rodents.
- (2) Practical immunity from attack by insects from other sources.
- (3) Protection of grain from atmosphere during periods of high humidity (*e.g.*, during monsoon period) thus preventing deterioration.
- (4) If grain is infested at time of receipt it can be fumigated easily in bins and further damage thus prevented. Where practicable sunning can be carried out before storage in case of infestation.
- (5) Economy in gunnies which may be returned for fresh supplies and which can be disinfested by fumigation before refilling for issue.
- (6) Provided grain is not damp and is not infested by insects at time of storage, it may be kept indefinitely without deterioration.

(B) Misconceptions about bulk storage

- (1) Bulk storage does not prevent "heating". If grain is damp when introduced, serious damage can occur if care is not taken.
- (2) Bulk storage does not prevent insects breeding in stored grain and weevil damage can in fact result in the development of "heating".
- (3) Cheap construction resulting in bin walls or roof not being thoroughly water-proof will entirely nullify the advantages of bulk storage.

(C) Type of construction

Ferroconcrete construction of the type employed at Muzaffarnagar (design of Concrete Association of India) is probably ideal but supplies of concrete and

steel are entirely inadequate for the demand for grain storage. An alternative is available in the form of a brick structure faced outside and inside with water-proof cement. A block of 525 units each of 1,000 maunds has been partially completed during 1944 at Shamli (U. P.) by private enterprise at a cost of less than Re. 1 per maund of storage space. This latter is entirely above ground while the former are sunk 5 feet below ground level so that only a 3 feet lift is required to the bin top. A series of stairs leads to the top (14 feet above ground) of the Shamli bins.

Another alternative is suggested below and the choice of design must depend on local conditions, the general principles being the same. The chief objection to the above designs is the necessity for emptying bins by hand through the man-hole. This can be avoided by the use of an exit spout at the floor level from which the bulk of the grain will empty by gravity and can, if desired, be bagged directly from the spout. Such a modification entails:—

(a) Base of bin should be at least 3 feet above ground level.

(b) A solid block of bins cannot be built but only rows of pairs each bin having one wall open to the road and fitted with exit spout.

Whether the advantage of ease of emptying even in wet weather outweighs the extra building cost and larger area required is again a matter for local consideration. Whichever design is decided the following are essential points:—

(1) All inside corners to be rounded off for ease of cleaning and removal of any insects from empty bin.

(2) Man-hole door at top to be double-flanged to prevent rain entering.

(3) Roof top to be slightly sloped so that no water accumulates on top of bin.

(4) Spout exit, if included, must not be a trap for rain water.

(D) Size of bins

Since no mechanical devices are immediately available in India and since the grain trade, particularly throughout Northern India, is used to dealing in quantities of 500/1,000 maunds as customary storage units it is considered that a unit of about 1,000 maunds (37 tons) would be most convenient. The number of unit cells on any one site is a matter for local consideration. At Muzaffarnagar the *khattis* have been designed partly below ground to aid filling. For ease of emptying the capacity of bins is limited to about 400 maunds and the height inside to 8 feet. At Shamli the capacity is 1,000 maunds and the inside height about 14 feet. This results in greater difficulty in emptying. If the proposed spout emptying design is used the height is not of great importance except for economy of ground space. A height of about 14 feet (*plus* 3 feet for base) could be adopted at most sites while in congested areas such as Bombay the economics may justify an internal height of 18—20 feet. With such a limit a unit of 1,500/2,000 maunds could be used for additional economy in materials. No difficulty should be found in getting labour to carry bags up steps to the bin top as the height is of the same order as the normal stacking height of bags (18 high) in Bombay. It is also possible to facilitate such operations by use of block and tackle gear. Alternatively portable conveyer belts operated manually can be used, the grain being cleaned at ground level and then lifted on the belt and discharged into the bin.

(E) Economics

Bulk storage of grain in modern large scale silos as a commercial venture depends for success on the number of turnovers per year and is, therefore, out of the question at present in India. Even if materials were all available and time permitted such construction, the cost would not be much less than Rs. 5 per maund of storage space. In comparison, the proposal for bulk storage of grain in bins of the *khatti* type shows a highly favourable return. Taking an approximate cost of construction at annas 15 per maund for the Shamli type and say Rs. 1-4-0 for the modified type with bottom spouts the capital expenditure can be recovered by a charge of annas 4 or annas 5 per maund, spread over five years. This allows for only a single charge of grain

going into each bin annually and frequently this minimal rate will be exceeded. Maintenance is very low and other charges the same whatever storage is used.

Emptying of sacks is not necessarily an extra item in cost because bulk storage is intended mainly for extended periods of storage and, as has been pointed out earlier, the best place for this is near the source of supply. Cleaning of the grain is necessary at some stage and under present conditions it is usually carried out as the last operation before the grain goes to the consumer. This involves the unnecessary transport of many thousand of tons of dirt by road and rail. By cleaning the grain at the source this can be avoided and if bulk storage is used for the clean grain there is no extra cost in unbagging.

It is desirable that a common standard should be used throughout India but this does not necessitate a single size or shape of bin being used everywhere. So long as the general principles are followed modification of detail can be made to suit local conditions.

In order to assist those who wish to adopt this scheme a model plan has been prepared by the Consulting Architect, Central Public Works Department. It can be obtained from the Food Department, New Delhi.

CHAPTER V

STANDARD GODOWNS FOR BAG STORAGE

Permanent Type.—The following basic design is suggested for stores of a permanent type to be constructed for bagged cereals.

Site.—Selection of site must be a matter for local decision and subject to the approval of Public Works Department as regards drainage, foundation requirements, etc.

Plinth.—It is desirable that the floor of the godown should be above ground level the height depending on local meteorological conditions. On a prepared foundation a layer of lime concrete of at least 4 inches in thickness should be laid. This should be covered with at least 1 inch of water-proof cement concrete or with stone flags. A layer of bitumen can be brushed over the lime concrete as an additional safeguard against moisture.

Walls.—Standard 13 1/2" wall (1 1/2 bricks) is sufficient. A damp proof course should be inserted. Inside walls should be plastered to a smooth finish and all corners rounded off. If bricks are very porous it may be advisable to use water-proof cement on inside walls but this gives a less smooth surface. Cement dipping may alternatively be used for porous bricks, or a thin bitumen wash on outside walls followed by sand before drying.

Height of walls should be at least 18 ft. to allow stacking up to 15 bags.

Drain Pipes.—Open drain pipes should be cut away 3 ft. above ground level or fitted with 1/2 inch mesh wire netting to prevent access of rodents to the roof.

Windows.—Clerestory type windows just below the top of the wall should measure approximately 3 1/2 ft × 1 1/2 ft. One window per 15 ft. should suffice for ventilation. Wire netting of 1/2 inch mesh can be used to keep birds out and the window may be fitted with glass to provide light. The window must be capable of opening for ventilation.

Doors.—Hinged wooden doors opening outwards and fitting closely to ground (1/4" maximum free space). Doorway should be about 6 ft. wide to permit coolies crossing in and out if necessary. To prevent rats gnawing the wood the bottom 4 inches of doors may be fitted with tinplate on both inside and outside. One sheet passing under the door should be used for both sides and should overlap the open edge of the door. Position of doors should be arranged so that the doors open on the alleyways between stacks. Any single stack of bags can then be unloaded without disturbing the others.

Verandah.—Covered verandah on loading side of godowns with roofing about 8—10 feet above floor level is a convenience for handling grain and should be 6—8 feet wide. Flooring should be 1 1/2 inches of cement concrete or stone flags.

Roofing.—Mangalore tiles, cement tiles, galvanised iron etc., may be used according to local availability and cost. The essential feature is protection from rain.

Size of Godown.—The size depends naturally on the amount of grain to be handled but it is preferable to have two or more godowns rather than one very large single chamber in order to reduce possibilities of cross-infestation of stocks. It is considered, therefore, that the maximum length should not generally exceed about 70 ft. for one chamber. Lengths of 100 ft. or more can be divided into 2 or 3 separate compartments by dividing walls. In deciding the length attention should be given to the size of stacks (*i.e.*, about 15 ft. × 15 ft.) with alleyways of 1 1/2 to 2 ft. between each and between wall and stack. Thus a 70 ft. length allows of 4 stacks of 15 ft. base with 5 alleys of 2 ft. each.

The width is even more important and apart from roof span considerations it should be limited preferably to about 20 ft. allowing for one stack of 15-16 ft. with alleyway of 2 ft. at each side. If for special reasons a wider chamber is required it should be about 36 ft. allowing for 2 stacks of 15 ft. and 3 alleyways of 2 ft. each. If this is done doors on both sides of the godown are desirable to facilitate unloading.

Layout.—This must vary according to sites available but it is suggested that three such godowns may be built in the form of three sides of a square with verandahs and doorways on the inside. This provides a courtyard which is useful for drying damp grain, etc.

It should not be used generally for sunning to kill insects which would be driven into the godowns. A wall may be constructed along the fourth side to complete the enclosure and if so two gateways should be made for carts.

Capacity.—Dimensions of 70 ft. × 20 ft. allow for four stacks (15 ft. × 15 ft.) per godown. This represents approximately 5 bags of 3 ft. length × 10 bags of 1 1/2 ft. width *i.e.*, 50 bags per layer. Stacking to 15 bags in height gives 750 bags per stack. One godown will, therefore, hold 3,000 bags of this size. A unit of three godowns should hold about 800 tons.

Cost.—It is not possible to give more than an approximate idea of costs but from information collected from different Provinces it appears that such construction should be possible at a cost of about Rs. 6,000 to Rs. 10,000 per godown excluding cost of site and levelling, *i.e.*, say Rs. -/13/- to Rs. 1/6/- per maund.

Fumigation.—Such stores cannot be used for fumigation owing to roof leakage of gas and even if airtight would be uneconomical owing to the large proportion of empty space under the roof. They can be adapted by building in a ceiling of wood (tongued and grooved boards), of asbestos sheeting or of fibre board. All joints must be carefully sealed. With board roofing it will be found that a 1" strip of bitumenised paper may readily be applied below the joint and this gives quite a good seal. If the godown is designed for fumigation the windows must be made to open from the outside.

Building godowns of the above type in the form of hollow squares of 70 ft. × 70 ft. leaves two empty spaces of 20 ft. × 20 ft. at the corners. It is suggested that these be used (i) for office and for (clean) bag store of total area 20 ft. × 20 ft. and (ii) for small fumigation chamber say 14 ft. × 14 ft. × 10 ft. to be used for fumigation of infested empty bags (before transfer to bag store) or of small parcels of infested grain. Effective fumigation of large amounts of bagged grain is difficult to achieve (see Chapter XII).

Fumigation is discussed in a later chapter but the point is conveniently noted here that a suitable fumigation chamber can be incorporated in this layout.

It must be understood that the stacking arrangements given are, as stated, for bags of 3 ft. in length by 1 1/2 ft. in width. There is considerable variation in volume of bags even of the same grain and it is not possible to give measurements that would meet with conditions in all areas. It will be noted, therefore,

that a width of 20 ft. in the godown gives 2 1/2 ft. clearance at each side if the stack base is exactly 15 ft. This godown width is deliberately designed to allow for some variation. So long as it is possible to pass between the wall and the stack inspection can be carried out. That is the essential point.

As regards height the figure of 15 bags is the maximum for prolonged storage. In some districts stacking is done only to 10 bags high while in others 18 bags is the standard height adopted by the trade. What is required is a reasonable compromise between economical use of available space and ease of handling and inspection.

Again it is emphasised that the layout of three godowns is only a suggestion for those to whom this size of unit is suitable. Those who require godown accommodation for say 10,000 tons of grain would, of course, construct larger buildings for economy. A plan of three alternative layouts has been prepared by the Consulting Architect, Central P. W. D. Blue prints are obtainable from the Food Department, New Delhi.

Temporary Type—"Lahore Shed"

For those areas where there is an urgent demand for covered accommodation of a temporary nature the "Lahore shed" designed by the Army is suitable and can be constructed very quickly. Inclusive of concrete plinth this type of building takes less than 14 days to construct. It is essentially a building of semi-circular cross section 100 ft. in length, 40 ft. wide and 20 ft. high and is formed of galvanised iron sheeting on semi-circular timber frames which are ingeniously constructed from small pieces of scrap timber. Full details can be obtained from the Food Department. The life is estimated to be at least five years, the capacity being about 500 tons.

This temporary accommodation should not be preferred to permanent godowns where the latter can be justified. It may be mentioned that in many areas private individuals have offered to construct permanent types of godowns, to Government specification, for grain storage. The individual gets the advantage of priority release of the necessary raw materials at controlled prices and the Province or State is relieved of the necessity of financing the capital cost and of attempting to estimate the period during which the capital must be written off. Such offers are made naturally with a view to ultimate use of the structure in private trade, and they are to be encouraged as being mutually beneficial.

CHAPTER VI

GRADING OF GODOWNS

Having laid down standards we can now proceed to examine present storage in order to assess its merits and faults. First of all I want to be quite certain that no wrong impression is obtained. Most of the godowns in India today are not entirely satisfactory but there are excellent stores not bearing any superficial resemblance to our standard which has been achieved with full freedom of choice in design. Remember that in practice the three things that matter are freedom from damp, proof against rodents, and availability of means of ventilation. The presence of insects is a question largely of hygiene.

I suggest that all Provinces and States do what some have already done, *i.e.*, inspect all godowns used for grain storage and classify them into the three following grades:—

Grade 1.—Suitable for prolonged storage throughout the year.

Grade 2.—Suitable for short term storage even in monsoon period and may be used for long term storage if special care is taken of stocks.

Grade 3.—Not suitable for monsoon storage but may be used for short term storage in emergency and outside monsoon period.

By appropriate repairs it may be possible to up-grade a store and this should be undertaken whenever practicable.

I am not going to try to give you a list of all the possible faults in the many different kinds of buildings used for grain storage to-day, but if you make a **FIRST INSPECTION REPORT** under the following headings you will include all the main factors.

FIRST INSPECTION REPORT.

Name and address
 Present or previous use
 Access (road and rail)

Measurements

Length }
 Width } Shape
 Height }
 Capacity }

TYPE OF CONSTRUCTION.

Plinth
 Floor
 Walls
 Roof and drain pipes
 Doors
 Light and ventilation

HYGIENE.

General
 Rodents
 Insects
 Damp

GRADE AND SUMMARY.

Signature of Inspector.

Date

Reverse of Report

Repairs required:

- 1.
- 2.
3. etc.

Do not rush off to get several hundred printed forms. It is unnecessary and will frequently be useless because the space needed for each item will vary a great deal. Put the above list in your notebook and keep it for reference. When inspecting write the heading, then your observations, then the next heading until you have finished. Be concise—this is not a literary essay.

I have called this a First Inspection Report to distinguish it from the Routine Inspection Report which will subsequently be made at regular intervals mainly on the general hygiene and on the condition of stocks. This First Inspection Report should be made before any premises are taken over and a Second Inspection Report will deal with the premises after any necessary repairs have been carried out. At first many of the stores will be already in use and under such conditions two separate reports should be issued, a First Inspection Report and a Routine Inspection Report. Do not confuse the two. I shall deal with the Routine Inspection report later but some observations on the First Inspection Report may be helpful.

First of all measurements—it is quite easy with a little practice to take paces of 36" instead of the normal 30" and to estimate floor area by this method. Give the figures in feet. Height is more difficult and is misleading. As a guide consider the ordinary door height which is usually 7 ft. and you will find that it goes often just a little less than halfway up the wall. This would give a height of 15-16 feet, often guessed as 20 ft.

I have included "Shape" because quite a lot of stores are formed of several sections of different floor area and instead of length and width one can only give the combined area of each section, *e.g.*,

Section 1. 20' x 15' = 300 sq. ft.

Section 2. 20' x 40' = 800 sq. ft.

Section 3. 20' x 15' = 300 sq. ft.

in which case you would bracket length and width inserting one figure of 1400 square feet. A rough outline of the shape will then give to any reader a clear picture of the premises.

Capacity is also wanted and there are many ways of calculating this. If you can stack 15 bags high you can take the floor area in *square yards*, double it and deduct 10 per cent. to get a rough estimate of the *maximum* capacity in tons. If you can stack only 12 or 8 bags high your capacity will be 12/15 or 8/15 of this value and so on.

Example.

Width—6½ paces = 6½ yds.

Length—23 paces = 23 yds.

Floor area—149½ sq. yds., say 150 sq. yds.

Maximum *Capacity* is then 300 tons less 10 per cent. = 270 tons, assuming height of stacks is 15 bags.

If ceiling is low and 8 bags is the maximum height the figure will be $8/15 \times 270 = 144$ tons.

This is only an approximate figure. Give a low rather than a high estimate. Remember that in a store with a flat ceiling sufficient room must be left for coolies to operate, so the stack height will be correspondingly lowered.

Under Hygiene will be noted the general condition and cleanliness of the store, confirmation of presence or absence of rodents, insects or dampness some of which will have been shown already, *e.g.*, rat-holes in floor.

The Summary should be brief, *e.g.*,

Grade 1.—If thoroughly cleaned and doors made rat-proof, or

Grade 2.—Subject to repairs detailed on reverse, otherwise grade 3, or

Grade 3.—Roof leakage in wet weather, soil floor and rat proofing impossible.

Avoid use for grain except in emergency.

These examples naturally refer to three different premises.

On the reverse of the report sheet should be listed in detail the action needed in the way of repairs so that these can be carried out in your absence. Take the store-keeper with you and point out the faults when on inspection, explaining exactly what is needed. Avoid any suggestion that he is responsible for the faults. You cannot function without his co-operation and must not start by antagonising him.

The presence of grain insects in a first class structure means that it cannot be Grade 1, for prolonged storage. But if it has smooth walls and floors much can be done by physical cleaning which is frequently neglected. Whitewash will neither disinfest nor disinfect but it is useful in increasing the light and in enabling insects to be more easily observed on the walls. Do not however apply one coat on top of another without scraping as you will merely provide a refuge for insects. Methods of treatment will be discussed later.

CHAPTER VII

GENERAL HYGIENE IN GRAIN STORAGE

Let us assume we have a Grade 1 or a Grade 2 store clean and ready for reception of grain. Stacking arrangements must be decided before the grain arrives and it is useful to have a card showing the stacking plan or to have stack bases marked out on the floor. Both may be done. Unless the building is specially constructed it is unlikely that stack bases exactly 15-16 ft. square can be fitted in economically. The arrangement is largely a matter of common sense bearing in mind the need to leave alleyways round each stack for inspection. It has already been observed that a 15 ft. stack base leaves a 2 1/2 ft. alleyway in the standard godown. This is deliberate to allow of different bag sizes. The essential is to leave room for inspection which at the same time fulfils the requirement of ventilation.

Some examples are given below for guidance.

Floor	Stacks
1. 12 ft. × 20 ft.	1 of 8—9 ft. × 16 ft.
2. 40 ft. × 30 ft.	2 of 17 ft. × 28 ft.
	or 4 of 17 ft. × 12 ft.
3. 50 ft. × 50 ft.	4 of 22 ft. × 22 ft.
	or 6 of 22 ft. × 14½ ft.
	or 9 of 14½ ft. × 14½ ft.

In the first example the height of the stack will be limited by its narrow base. In the last example 4 stacks could be planned for a ration store holding stocks only for about a month; 6 stacks is better for prolonged storage periods; 9 stacks is rather small a base unless the height is limited by a low ceiling.

We must now provide dunnage. Even a well constructed cement concrete floor which appears quite dry will transmit some moisture to grain in humid weather so that ventilation below the stack is wanted. Timber baulks of three inch square cross section will suffice to raise the bags off the floor. Failing that bamboo poles may be used but more are required because of the smaller diameter. In some Middle East countries loose bricks have been used for this purpose.

Failing these, matting is better than nothing, but must be replaced at intervals and *not* covered by a new layer when damaged or damp. Some districts use *bhusa*, rice husks or sand to insulate the bottom bags from ground moisture. These do not assist ventilation much and in time moisture will penetrate through. If used they must be removed and replaced with fresh material at regular intervals—each time the store is emptied. Old *bhusa* or rice husks should be burnt. A layer of about a foot of loose dry sand is helpful on a soil floor as rats have some difficulty in getting through from below. Any bag wetted by rain, seawater, etc., must be laid aside on receipt. The contents must be spread in the sun to dry before rebagging in dry bags. If drying is impossible the damp bags must be allocated for immediate milling or consumption to avoid deterioration of the grain. With *maida* or *atta* water forms a cake on the outside layer and on emptying the wet portion remains attached to the wall of the bag, the dry free-flowing portion being available for rebagging.

Any bags showing signs of insect life on the outside should be separated from the remainder and stacked in another store. Immediate disposal instructions should be requested. If the whole consignment is affected it should not go into any long term storage depot.

In stacking the bags may all lie in one direction or each bag may be placed across instead of along the one below. For good cross stacking the width of bags should be half the length, otherwise difficulties occur. There is not a great deal of difference in the amount of ventilation given by the two methods and there is, therefore, no particular reason for changing from whichever is locally operated and understood.

"What height may I stack?" is a common question and is invariably answered according to the local custom. The answer in different parts of the country varies from 8 bags to 20 bags (the latter being a larger base of course than 15 ft. square) with an assurance that either 8 or 20 is the limit for safety of stack and to prevent bags bursting. For long term storage I do not like to exceed 15 bags in height. To achieve this some experience in stacking is needed and it is not the simple business it appears to be when done by a well trained gang of coolies. If difficulty is experienced in getting secure stacks of 15 bags high be content with 10 or 12 bags until the labour gets experience. *If a stack is not neat it is dangerous.* If too big a strain is put on the lower bags the first sign of damage is a straining of the jute threads along the side seam, giving the appearance of "laddering". If this shows the stack height must be reduced at once. With normal qualities of gunny this should not occur within a year at a height of 15 bags. Rats, by tearing bags and causing leakage, have been known to cause the collapse of stacks originally securely built. Occasionally torn bags will be received and these must be repaired before being put in the stack. If they are partly empty through leakage they should be made up to normal or they will produce an uneven and dangerous stack. Only by constant and careful supervision can you ensure that full attention is given to all these most important details. It is not too much to say that good conservation is largely a matter of taking care of the many little matters of routine that give opportunity for carelessness. If you want to achieve success however you must carry your godown-keeper and his staff with you. Little will be achieved if they regard

you as somebody whose job it is to find fault with them. Your job is to help them.

Flour (*maida*) or *atta* must not be stacked more than 12 bags high or it will cake badly. The best stores and the most ventilation should be provided for these milled products.

If grain is being screened for cleaning purposes before storage the screenings must be destroyed by burning.

Any insects present will be concentrated in the fine screenings (although some will remain in the grain) and it is false economy to accumulate these for some weeks in the hope that a sale may be obtained for them as fertiliser. Sweepings from incoming trucks or wagons must be collected and screened daily. This process must be repeated on discharging grain from the warehouse and on no account should old sweepings be kept in the store.

In addition to the stock-books, etc., it is useful to have a tally card on each stack with date of receipt, origin, kind of grain, number of bags. The reverse of this card should be used for a record of inspections made. The date of inspection, condition of stack, any recommendations made and the signature of the inspector should be written on this card each time the inspector visits the store. The cards should be numbered, e.g. 6/3/1 would indicate godown 6, stack 3, card 1 and when this stack is despatched a new card number 6/3/2 would take its place for the next consignment and so on.

The inspector will include the above data concerning the stack in his **Routine Inspection Report** which can be prepared on the following lines:

Name, number and address (of store).

General hygiene

Insects

Rodents

Dampness

Remarks or recommendations

Signature of Inspector

Number of stack

Kind of grain

Quantity of grain

Quality of grain

Date

Such inspection should be made at least monthly and in heavy monsoon areas fortnightly during the rains if possible.

Allocation of issue from the godown will normally be in chronological order of receipt but if any one stack shows signs of insect damage (not just one or two insects—that is the first warning) it should be recommended for immediate issue and consumption or milling, no matter how short the storage period compared with other stocks. This is most important and if it receives proper attention a great deal of wastage and cross infection can be avoided.

I would also commend to the surplus areas the view that it is not unfair to the local population to send the best quality of grain away. This exported grain may have to be stored under bad climatic conditions for several months after it leaves the surplus area. If it is only slightly attacked it can be used locally without appreciable loss and without complaint provided speedy allocation is granted, but in the far distant deficit area it is not possible to allocate all they receive for immediate consumption and a delay of several months will involve heavy loss in climates such as Bombay, Madras or Travancore—at any time of the year. Recipients should be warned if the supplies consigned to them are affected with living insects so that they may make some advance arrangements about disposal.

Used bags are a common source of insect infestation. These should never be stored without thorough brushing inside and outside and where possible they should be spread in the sun to destroy insects. Alternatively they may be fumigated (see p. 33) or subjected to heat in a small chamber raised to a temperature of 150°F. The bags should be kept at this temperature for at least half an hour and should be spread out loosely in small heaps or on racks so that even penetration of heat is ensured. Steam pipes may be used for heating such a chamber.

INSECT PESTS OF STORED GRAIN.

There are more than fifty species of insects which attack and damage stored grain but only about a dozen are of primary importance. A full description is given in Imperial Agricultural Research Council Miscellaneous Bulletin No. 57 "Stored Grain Pests and their Control", together with coloured plates to aid in identification, so it is not necessary to give more than an outline of the main points here.

Some species of grain insects have a life-cycle as short as a fortnight while others require over a year to develop from egg to larva, pupa and finally adult stage. The life of the adult again may be a few days as with moths or several years as with some of the beetles. A short life-cycle means more generations per year. The number of eggs laid by each female also varies from a few dozen to several hundred and these species with a short adult life do not necessarily lay fewer eggs. They may compensate for a short life by laying many eggs in a few days. Whatever the life-cycle may be it is always prolonged under unfavourable conditions and there may indeed be a dormant period at one stage by which the insect succeeds in surviving an inclement winter. Warm, humid weather, as typified by coastal areas or by monsoon periods, is ideal for insect development. Low temperatures slow development, very high temperatures kill insects (145°F. for 15 minutes), and dry conditions (low Relative Humidity) are unfavourable. Thus to give the life cycle of any insect one must know the conditions. The same species may complete the cycle in a month in Madras at any time of the year, and in the same time in Calcutta in July, but may need 2 or 3 months in Delhi during the winter. For reference purposes the optimum life-cycle of the principal primary pests and a few other common grain insects is tabulated below. The figures given are for very favourable conditions only and the purpose is to show how quickly damage can increase in a few weeks.

TABLE 8

Name of Insect	Maximum number of eggs laid	Minimum Incubation period (days)	Minimum Larva Stage (days)	Minimum Pupa Stage (days)	Minimum Life-cycle (weeks)	Maximum No. of generations possible per year
<i>Calandra oryzae</i>	400	5	20	3	4	12
<i>Calandra granaria</i>	400	5	19	3	4	12
<i>Rhizopertha dominica</i>	500	3	20	5	4	12
<i>Trogoderma granaria</i>	120	3	20	4	4	12
<i>Tribolium confusum</i>	1000	4	18	5	4	12
<i>Tribolium castaneum</i>						
<i>Sitona surinamensis</i>	100	7	22	6	5	10
<i>Tenebroides mauritanicus</i>	1000	7	50	8	9	5
<i>Tenebrio molitor</i>	500	7	300	10	45	1
<i>Sitotroga cerealella</i>	400	4	14	5	3	17
<i>Corcyra cephalonica</i>	200	5	28	9	6	8
<i>Plodia interpunctella</i>	350	2	30	4	7	7
<i>Pyralis farinalis</i>						
<i>Bruchus species</i>	150	3	12	4	3	17

In practice conditions are seldom so ideal as to permit the maximum number of generations to develop without hindrance and shortage of food would become the limiting factor if nothing else did. However, it can be appreciated from these figures how serious can be the damage resulting from a few months of storage under warm humid conditions. This is the principal reason for routine monthly inspection of stocks and for prompt action being required to issue, for immediate consumption, grain showing signs of insect damage.

This table explains the common view that infestation by insects appears only towards the end of the monsoon. It is the second generation that has bred through quickly under favourable conditions from perhaps only a few stray survivors of the dry hot weather before the monsoon. This sudden huge increase in numbers gives the false suggestion of spontaneous generation. Every insect has a mother just as every human has a mother.

The main characteristics and simple methods of identifying the important insect pests are detailed below.

Grain Beetles

Calandra oryzae (*Sitophilus oryzae*) the Rice Weevil, is a beetle usually about 1/8" in length but size is variable and adults bred on maize are frequently larger than those from paddy or wheat. Its chief characteristic is the long proboscis resembling the trunk of an elephant. This insect is likely to be confused only with *Calandra granaria* (*Sitophilus granaria*), the Grain Weevil, but can be easily differentiated by the four light reddish patches on the back, and by the pitting of the thorax. *C. oryzae* has round pits and *C. granaria* has elongate pitting—easily seen with a lens. The differentiation in India is not important as the Grain Weevil is rare in occurrence. In sub-tropical areas where both species flourish it may sometimes be important to distinguish between them because *C. oryzae* can fly well while *C. granaria* has only vestigial wings and cannot fly.

These weevils lay their eggs in a tiny hollow excavated on the grain and then seal the aperture so no attack is noticed. The larvæ spend their whole life inside the seed and emerge only after pupation. *Holes in grain are emergence holes, not entrance holes.* Apparent damage is, therefore, always less than actual damage. The adults also eat grain, and all cereals are attacked.

Rhizopertha dominica, the Lesser Grain Borer, is another major pest in India. The title "lesser" refers to size and not to importance. *R. dominica* is smaller than *Calandra*. It is easily identified when examined in profile. The head then appears as an inverted triangle placed below the thorax. From above the thorax appears round and may be mistaken for the head.

This beetle lays eggs on the grain, and the larvæ hatch out in the open, feeding first on grain debris and then, still quite tiny, boring into the seed for the remainder of the larval and the pupal periods. Again holes are exits and damage is greater than it appears to be. Adults also feed on grain and can bore into timber.

Trogoderma granaria, the *Khapra* Beetle, is acclimatised to conditions of higher-temperature and lower humidity than other grain insects; so it flourishes in the Punjab and Sind. It is not restricted to these Provinces, however, and can breed actively in most parts of India. The adult is about 1/10" in length. Identification is not difficult and confusion is only likely to arise with closely related species which are not generally found in grain. From above it appears ovoid and distinction between head, thorax and abdomen is not at once obvious. The presence of *Khapra* beetle is, however, always evident from the cast skins which result from the moulting of the larvæ. With a heavy infestation these cast skin may form a layer several inches deep on sacks and floor. The larvæ themselves aid identification, being free living and moving generally to the surface of the grain. The young larva is almost white in colour but the full grown larva is light brown and covered with fine hair. It is found frequently on the walls of godowns, nearly always climbing upward. Pupation takes place in cracks and crevices in the floors, walls and roofs of buildings and in the seams of bags.

The grain is attacked at any part but very frequently the embryo is selected and germination of the grain may be prevented long before any serious quantitative damage has occurred. Seed grain, thereto, should be specially protected against *Khapra*. The main damage is done by the larvæ.

Tribolium castaneum and *Tribolium confusum* are two almost identical Flour Beetles which do serious damage to milled products, including rice, but which do not attack whole undamaged grain. Differentiation between the two is unnecessary. Their presence in grain is not serious as they live only on broken grains or on those damaged by one of the primary pests, but it may indicate previous attack by these. They are very common in stores and mills. *Maida* or *atta* can be very badly damaged. The adults and the larvæ may be sieved out but the eggs and the frass (excreta) remain behind and the latter causes an objectionable smell and taste. The adults are reddish brown in colour and about 1/7" in length and very active. They are only likely to be confused with another flour beetle *Latheticus oryzae* which is more slender, slightly smaller and lighter in colour.

The larvæ of these flour beetles are free living. They are slender worms and when full-grown are yellowish in colour and about 3/16" in length.

Silvanus surinamensis, the Saw-toothed Grain Beetle, is so called because of the distinguishing serrated appearance of the thorax on both sides. It is smaller than *Tribolium* species, more slender and even more active. It is not usually a primary pest on grain but can do much damage. It is found frequently in dried fruits and packaged cereals.

Lamophleus minutus as the name indicates is very tiny. It is readily distinguished by the length of the antennæ which appear almost as long as the whole body. It is also a secondary pest.

Tenebroides mauritanicus, the Cadelle beetle, is common in grain stores and large numbers indicate bad hygiene because although a large number of eggs are laid this only happens over a long period. This adult beetle lives a year. The full-grown larvæ are about 3/4" in length. They are dirty white in colour with distinctive black tips at the end of the abdomen. The Cadelle larvæ frequently bore into timber in grain bins, in mills and in stores. These burrows also form a refuge for other insects. The adults are about 1/3" in length and are only likely to be mistaken for another black beetle, *Tenebrio molitor* which is about 1/2" in length. *T. molitor* is known as the Yellow Meal-Worm because the larvæ, which exceed an inch when full-grown, are yellow in colour. *T. molitor* has only one generation a year and its presence in large numbers is even more significant of poor hygiene. These beetles and larvæ are mainly scavengers and are to be found often under matting or other dunnage, but they feed voraciously on whole and milled cereal products when given the opportunity.

Grain Moths.

Sitotroga cerealella, the Angoumois Grain Moth, is most destructive to grain. It is smaller than the other moths mentioned below and has distinctive fringed wings, brown in colour. Eggs hatch out tiny larvæ which burrow into the grain and emerge as moths after pupation, leaving an empty husk. In bulk storage control can be effected by turning over the grain as the moth cannot penetrate the grain and lays the eggs near the surface. If this infested grain is buried below a foot depth of other grain the newly emerged moth will not be able to reach the surface.

Corcyra cephalonica, the Rice Moth, is slightly larger and of a more greyish brown colour. Webbing formed by the larvæ makes a dense mass of silky fibre and grain which is typical of this moth.

Plodia interpunctella, the Indian Meal Moth, is easily distinguished by the whitish band across the inner half of the wings contrasting with the brown lustre of the remainder. On flour bags this band acts as camouflage by breaking the outline. The larvæ are free living and are of grey-white colour.

They attain a size of about 1/2". Tubular webbing is formed. The larvæ form pupæ on the outside surface of bags so the moth may emerge freely. The cocoons are usually to be found at the junction between two bags.

Pulse Beetles

Several species of *Bruchid* beetles attack peas, beans and grams doing an enormous amount of damage. They are frequently called Bean Weevils or Pea Weevils. Differentiation between the species is not important. Attack may occur in the field before harvest and the larva inside the matured pulse seed is not visible. This again has given rise to the erroneous view of spontaneous generation of insects. The adults are usually less than 1/4" in length and present a heart shape when viewed from above, tapering towards the head. They can fly readily and thus transmit infestation from store to field at or before harvest. The larvæ live inside the seed and emerge only after pupation so that the holes seen are again exit holes and do not represent all the damage.

Mites

Tiny, wingless, greyish-white, soft-bodied creatures are sometimes found in enormous numbers in damp grain or milled cereals. These are mites not insects, having eight legs and a body divided into two indistinct parts while adult insects have six legs and a distinct head, thorax and abdomen. Their presence indicates that stocks are going out of condition and that hygiene is not up to standard.

To summarise the chief danger to whole grain of all types is due to *Calandra oryzae*, *Rhizopertha dominica*, and *Trogoderma granaria* species of beetles and to *Sitotroga cerealella*, *Corcyra cephalonica* and *Plodia interpunctella* species of moths. Pulses are attacked by *Bruchid* beetles which do not damage cereals. Milled cereals can be damaged by all the main grain pests but except in the case of rice, do not provide seeds for larvæ to develop in. There are two main pests of milled cereals, both beetles of the genus *Tribolium*, and a number of other secondary grain pests some of whom are indicative of bad storage conditions.

CHAPTER IX

INSECT DAMAGE TO GRAIN—QUALITATIVE AND QUANTITATIVE

The damage done by insects is of two kinds which can most simply be exemplified by weevils on wheat and flour beetle on rice.

In the first case the grain weevil makes a tiny hole, deposits an egg, and seals the hole so that it is not readily seen. The larva on hatching moves inward and spends the whole of the larval period eating the kernel while the grain appears whole and undamaged. After pupation the adult insect emerges from the seed. The typical weevil holes then seen are *exits* not *entrances*. Damage is also done by the adult eating both fresh grain and the residue from "holed" grains.

In the second kind of attack of rice by flour beetle both the adult and the larvæ feed on the outside of the rice and are indeed said to increase the polish on under-milled rice during storage. Actually they do considerable damage but it is not so readily observed. These flour beetles also feed freely on *maian* or *atta* and if present in large numbers cause a definite taint easily noted by smell and taste in cakes or *chapatis* after baking. This is due largely to the frass or excreta of the insects which cannot be sifted out from milled products like *atta* or *māida*.

This differentiation makes any accurate estimation of degree of damage very difficult and I can at once say that it is of little value to attempt an accurate quantitative estimation. Nevertheless it is necessary to have some idea of the significance of the various methods used and I propose to discuss these briefly.

The trade method of estimation is made by weighing these grains which show signs of damage (*i.e.*, holed grains) and expressing this weight as a percentage of the total. Before detailing the fallacies of the procedure I would

make it quite clear that in trade practice this is a useful method upon the results of which fairly equitable discounts can be made where only a relatively small amount of damage is recorded. It can also be carried out along with the other refraction estimations of dirt, foreign seeds etc.

The snags are:

(1) The percentage given is not the amount of damage but the weight of the attacked grain left by the insects. If the insects eat 66 per cent. of each grain attacked, the trade damage recorded will be half that recorded where only 33 per cent. of each attacked seed is eaten.

(2) If the damage is caused by *Calandra*, *Rhizopertha* or *Sitotroga* species these grains containing larvae will be overlooked.

By counting the number of the "apparently damaged" grains and expressing this as a percentage one can avoid the first difficulty but this is a tedious process. Then a number of whole grains must be split open to ascertain the proportion containing larvae, an even more tedious job. I have found that over many such counts made in grain containing actively breeding *Calandra* species this second figure was approximately the same as the first. In other words the "apparently damaged" grain figure could be doubled to get an approximation to the total number of attacked grains. But even if we took this liberty the first count is too slow and laborious to be used as a routine. At least 1,000 grains would have to be counted to assess with any accuracy an infestation of about 1 per cent. because about 10 damaged grains must be counted.

Where there are obvious signs of heavy damage this method can be used for a quick assay of the position, e.g., at 15 per cent. only about 50—100 grains need be counted to get the figure of apparently damaged grains. If *Calandra*, *Rhizopertha* or *Sitotroga* is the responsible agent and is actively breeding this figure can be doubled to give the total number of damaged grains, i.e., 30 per cent. Such figures are much more common than they should be and use of them conveys even to the uninitiated the need for urgent disposal.

In trade assays the sample is obtained at the time of receipt or despatch from a number of bags and can usually be taken as a fair average. It is very much more difficult to get an average sample during storage from either a bin or a stack because initially the infestation begins at one or more places and only gradually spreads through the mass. In bulk storage the insects tend to move to the surface and in bag storage to spread over the adjacent bags. No single bag or no single sample from a bin will be representative of the total.

In bulk storage samples must be taken from at least three points near the base, three about the middle and three near the top. This can be done by using a sampling tube which is a hollow tube of about not less than 1/2" diameter with a conical point to aid penetration. In one type a hole of about 3" x 1/2" is cut in the tube about 6" above the point and this opening is closed by an internal inverted tube which can be raised by a wire when the required depth has been obtained. The bottom end of the sampling tube then fills up with grain and can be withdrawn. In another type an inner tube runs the whole length and both outer and inner tubes have holes cut at intervals. By turning the inner tube until the two sets of holes coincide several samples can be collected at once. The inner tube is closed between each aperture to keep the samples separate. For most work the simpler sampling tube described first will be adequate.

To obtain something like an average sample from a stack of bags one must get samples from at least 5 per cent. of the bags. With a 15 bag stack (750 bags) about 40 samples are wanted, and without breaking the stack it is not easy to do this properly. By taking 15 samples diagonally across two faces of the stack and 10 samples from the second top row centre an approximation can be made but it will be biased by the large proportion of surface bags. An improvement can be made by sampling the second row down one side and it is usually possible to reach sufficient bags without disturbing the stack.

Whatever method is used remember that the sample is only approximately representative. Proper sampling is not easy and with bad sampling very erroneous conclusions will be obtained. Having obtained this sample you will find it too large to examine so it must be divided and again the necessity of getting a representative small sample must be stressed.

To do this pour the original sample out on to a table in the form of a symmetrical mound, and quarter this with a ruler or a piece of cardboard. Take one quarter and repeat the process several times until the required size of sample is obtained. The size will depend on the degree of infestation, only about 100 grains being needed for a 10 per cent. infestation but at least 1,000 grains for 1 per cent. or less. Therefore such a procedure is justified only when conditions are serious and it is necessary to know just how bad they are.

I emphasise again the fact that such figures as you obtain have not a great accuracy. Report your result as "No. of holed grains" or "Number of apparently damaged grains" is X per cent. Do not put "Weevil Damage" is X per cent. as that gives no indication of the method used. If you have also split grains to find those with larvae your final result should be expressed as "Actual number of grains damaged" is $(X + Y)$ per cent.

Let us now consider what use these figures may be. I have already mentioned that in heavy infestations they give a useful confirmation that action must be taken without delay. In a light infestation the actual figure will not be of much value because of the sampling and other errors and the importance lies in the need for careful inspection to avoid holding for long periods grain already infested. Ideally one would like to advise that no grain with any infestation should be kept in storage but such a suggestion would have little real value in areas where practically none of the grain received is entirely free of insects and where the stores are permanently infested. It is an objective to be kept in mind but before it can be achieved in deficit areas the standards which allow up to 2 per cent. of weevil damage (trade method) without penalty, over more than half the year, must be abolished.

Those in charge of storage should be informed of the trade analysis of the grain received. It is part of the duty of the Procurement staff to assess refraction and I do not propose to discuss the technique here. The "Weevil Damage" figure in the refraction should be reported to the store-keeper so that he has some idea of the possible danger involved in storage. As an additional check the storekeeper can be instructed to take small samples from at least 10 per cent. of the bags arriving at the store and to keep the bulk sample from any one stack beside the stack tally card. This sample if properly taken, will give the inspector a check on the reported insect damage and also an indication of the keeping qualities of that grain.

Unless there has been some treatment of the grain to destroy insect life no figure obtained by any method is static. The rate of increase is extraordinarily fast under favourable conditions since there may be five generations in a year each one a hundred times the preceding one in number of insects. This means that although it may take one or even two months to show say 2 per cent. attacked grains, the next period of similar duration will show 10 per cent. or even more, and so on.

When does grain become unfit for human consumption? It is a simple matter for a layman to decide that wet, mouldy, stinking grain is unfit for consumption, but with a lesser degree of moisture damage or in examples of insect damage it is a matter which can only be decided legally by a medical officer. In absence of any standard of measurement it may frequently be a matter of opinion, but it is the opinion of the medical authorities that counts. Do not, therefore, allow yourself to be inveigled into giving an official decision on such points. Refer to the local Department of Public Health for an authoritative opinion. I realise that this is placing an extremely awkward onus on a medical officer who may have no scientific method of judging the potential danger to consumers, but if a decision has to be taken it is clearly his duty as custodian of public health standards.

Before leaving this question, admittedly in an unsatisfactory state, I would point out that two great advantages of bulk storage are firstly the comparative ease of preventing insect attack of grain once it has been loaded into the bin in an insect-free condition and secondly the ease with which fumigation can be carried out in bins at an early stage thus preventing further damage. Let me give an example. If you receive into a bin 1,000 maunds of grain slightly infested and are desirous of holding this stock for some months you run the risk of the number of damaged grains increasing from something below 0.5 per cent. to at least 2.5 per cent. and possibly very much more. The actual loss in weight we shall assume to be half the original weight of grains attacked so the increase from 0.5 per cent. to 2.5 per cent. means that we have lost 1 per cent. of the weight of our original grain, i.e., 10 maunds costing about Rs. 100. At these figures it is economic to carry out fumigation, therefore, up to such an extremely high cost as Rs. 100 per 1,000 maunds in order to prevent a loss of as little as 1 per cent. of the original weight, represented by 2 per cent. of the grains showing attack from weevil. Fumigation cost in terms of the fumigant required should be less than half this figure, so it is justifiable at a very much lower price level than exists today.

Fumigation of grain in godowns is a much more difficult job. The buildings are mostly quite unsuitable for effective fumigation, and even if they were suitable the operation is more difficult, more dangerous, and more expensive than in bulk bins. This procedure of fumigation is considered in the next chapters.

CHAPTER X

PRINCIPLES OF FUMIGATION

There are three general types of insecticidal action involving the use of chemicals. The insecticide may act as a Stomach Poison like lead arsenate as used on fruit trees or sodium silicofluoride in locust bait. This method is obviously not applicable to insects feeding on grain which is destined for human consumption. Contact Poisons on the other hand like pyrethrum in mosquito or fly sprays and derris in agricultural dusts or sprays kill insects without being eaten or "inhaled". Unfortunately they are much less effective against hard bodied insects like beetles than the soft bodied insects for which they are used and also it is not possible to get at the grain insects very easily. We are left then with the third method of Fumigation in which the insecticide acts in the gaseous form and is taken into the insect body through the spiracles by which the necessary oxygen is obtained.

A book considerably bigger than this publication could be written on the principles of fumigation and I can only deal in a rather superficial manner with the general basis. My intention is to make clear that it is by no means an answer to all insect problems and that it is not a step to be initiated lightly.

It may be thought that in large masses of grain it is not possible for gases to penetrate because the space is largely filled by the grain. In fact the "free space" as the intergranular air space is called amounts to about 40 per cent. of the total volume with whole grains and may be up to 60 per cent. with finely milled products. This can easily be demonstrated by filling a glass container with grain and another of equal size with water. Nearly half the water can be added to the grain container before all the air is displaced and without changing the volume occupied by the grain.

This incidentally is the answer to those who think that by storing grain in bulk air is excluded and insects will die. A 1,000 maund bin occupies about 2,000 cubic feet and 800 cubic feet of air remain in the bin after it is filled with grain. This will satisfy a lot of insects for a long time.

Grain is alive or it would not germinate and being alive it is breathing, at a very slow rate, taking up oxygen and producing carbon dioxide. This process is greatly accelerated by moisture and in pits the wet grain round the walls may produce an appreciable amount of carbon dioxide. Also the growth of moulds, bacteria and insects reduces the oxygen and replaces it by carbon dioxide. This

ultimately makes conditions for insect breeding or living increasingly difficult but usually too much damage has been done before the desired effect is produced. This might be considered a natural kind of fumigation but the effect is probably as much due to the lack of oxygen as to the carbon dioxide. It cannot be relied upon as a general measure of control and it is expensive if one has to lose 2 per cent. of the grain from moisture damage to achieve this result. The obvious alternative of adding carbon dioxide artificially to replace air has been tried but it has not given satisfactory results.

I do not propose to discuss the mode of action of fumigants but from the practical aspect two important points have emerged from the work carried out on this subject. First, it is important to achieve a high concentration of gas quickly because insects can suspend respiration for prolonged periods and are liable to do so if they get a sub-lethal dose of gas. Second, insects may recover from apparent death after fumigation up to a period of 14 days or more with some gases, and on the contrary others may appear normal after fumigation but may die a few hours or days later.

It is necessary, therefore, to check the efficiency of any fumigation by collecting insects after the treatment and keeping them for a fortnight before finally deciding the kill obtained. It may be convenient to insert wire gauze containers amongst the grain at different places not readily accessible to the gas. These containers should hold about 50 insects each, of the type to be treated. At least one container should be kept unfumigated to ascertain the natural mortality.

Fumigation is not quite so easy as it may appear so far. Insects are cold blooded and their temperature is that of the surrounding atmosphere—or the grain which in bulk or large stacks does not change so quickly as the shade temperature of the atmosphere. At high temperatures insects are much more active and, therefore, breathe more rapidly, so that fumigation at 80°F will be easier than at 60°F. Either the exposure period or the dose can be reduced at the higher temperature, as illustrated in the table below:—

TABLE 9

Temperature	50°F	70°F	80°F
Dosage of ethylene oxide to cause 100 % kill of <i>Tribolium confusum</i> adults in three hours. (mgm./litre)	135	37	22

(Cotton "Insect pests of stored grain" 1941)

Some understanding of the relationship between exposure period and dosage is essential. At any given temperature the average insect will breathe a certain amount of air in an hour. If the air contains 2 per cent. of the fumigant gas the insect will therefore breathe in an hour twice as much fumigant as from air containing only 1 per cent. of the gas. In other words the factor that matters is concentration multiplied by time, known as the C × T Factor. This only holds within limits because if the time is too short the gas does not reach the insect and if the time is very long other factors operate. In general a fumigation lasting 48 hours should require only half the amount of fumigant needed for a 24 hour exposure. Usually it is more economical to increase the exposure period than to use more fumigant.

Now let us consider dosage in relation to the insect. A population of 100 men affected by poison gas will not all die at one moment. There will be individual variation and exactly the same thing happens with insects. Some die very quickly and some very slowly, the majority being in between the two limits. To get 100 per cent. kill it may be necessary to increase the dosage for a 98 per cent. kill by as much as 30 per cent. at a given temperature and exposure period. For this reason comparisons of efficiency are usually carried out on the basis of the Median Lethal Dose which is the dose required to kill 50 per cent. of the insects in a given time at a standard temperature. It may be noted that dosage in laboratory tests is usually measured in milligrams per litre and in practical work either in grams per cubic metre (Europe) or in ounces

per 1,000 cubic feet (U. S. A. and British Empire). It is, therefore, fortunate that these terms are inter-changeable and $x \text{ mgm/litre} = x \text{ oz./1,000 c. ft.}$

The table below gives the median lethal dose determined for four fumigants against adults of three species of grain insects. (Shepard, Lindgren and Thomas—University Mich. Agricultural Expt. Station, Technical Bulletin No. 120, 1937). The figures denote mgm. per litre of fumigant to give 50 per cent. kill of exposed insects (not in grain) at 25°C with an exposure of 5 hours.

TABLE 10

	<i>Tribolium confusum</i>	<i>Calandra granaria</i>	<i>Calandra oryzae</i>
Carbon bisulphide	61	40	26
Ethylene dichloride	37.5	138	31
Sulphur dioxide	5.7	5.7	17
Carbon tetrachloride	185	360	160

This illustrates clearly that the resistance of different species differs with the fumigant used, even when the species are closely related. (As ethylene dichloride is the fumigant recommended for use in India; it may be important that the most resistant of the above three insects is *C. granaria* which is rare in India. The dosage recommended in U. S. A. where *C. granaria* is comparatively common may, therefore, be reduced). This variation in resistance must not be overlooked when comparing different fumigants. Even in one species of insect it will be found that the resistance of the different stages—eggs, larvae, pupae, and adults—differs, sometimes markedly.

These are some of the difficulties that have to be considered in fumigation work, but there are a few others even more important in practice. All the dosages mentioned in this chapter refer to laboratory conditions which do not exist in practical fumigation. In particular these dosages are against exposed insects not hidden or protected by grain. In Chapter II, I discussed the equilibrium that exists between the water vapour in the air (Humidity) and the moisture content of grain. A similar relationship exists with other vapours such as fumigants, a proportion of which is rendered ineffective as a gas because it is absorbed by the grain. The relationship, as might be guessed, is different with different gases and also varies with different grains. Where the gas is very soluble in water the moisture content of the grain affects the absorption and also the retention of fumigant. Fumigants which are solvents for fats on the other hand are more highly absorbed by ground nuts, linseed, copra or soya beans than by wheat or rice. The greater the dosage needed for efficient fumigation the greater will be the absorption of gas and this may in some instances affect the grain (baking properties, palatability, etc.) or even the consumer.

In field work the insects are not in a standard glass container but in stores and bins which are much more difficult to seal. Only when one has tried to make a building gas-tight and has tested for leakage does one realise how very difficult it is. Allowance must, therefore, be made for leakage and also for absorption of fumigant by the surface of the walls, roof and floors. These reach an equilibrium with the fumigant just as grain does. This is not surprising when one recollects how walls and floors react to humid weather in the same way. Incidentally a smooth wall is preferable to a rough one which gives a greater surface for absorption. Also the more finely divided a product is the greater will be the absorption because of the increase in surface. This makes flour more difficult to fumigate than whole grain although it has a greater proportion of "free space" (50—60 per cent. of total volume).

This is a very brief review of the difficulties in selecting a fumigant, deciding a dose and exposure period, and finally in doing the fumigation which must

be recognised by anybody contemplating such operations. In particular it is difficult to recommend a dosage for general use and nobody should be surprised if some of the standard recommendations occasionally fail to give satisfactory results. One example from my own experience may be quoted. In determining the dosage necessary for cacao beans with hydrogen cyanide at Colombo in 1936 I assumed that the higher temperature would mean a lower dosage could be used than was found effective in London. But the first experimental dosage used failed and then the second until finally it was necessary to use the same level of dosage. The most reasonable explanation that could be found was the high humidity which made the moisture content of the gunny bags high and increased the absorption of HCN by the bags, although the possibility that the same species of insect, acclimatised to Colombo, were more resistant could not be excluded.

CHAPTER XI

COMMON FUMIGANTS

In this chapter I am going to review the chief fumigants used on a practical scale today. Most of them will not be used in India either because of non-availability or because they are too dangerous, but something must be known about them.

First of all let us see what our definition of the ideal fumigant would be and then we can more easily detect the weakness of these in common use. It should be:—

- (1) Highly toxic to insects.
- (2) Non-toxic to man.
- (3) Easily detectable.
- (4) Non-inflammable.
- (5) Not highly absorbed by produce.
- (6) Economical—either very low dose or very low price.
- (7) Transportable in non-returnable containers for ease of manipulation as well as cheapness.

Hydrogen cyanide.—I shall start with hydrogen cyanide—HCN—by saying that I do not advise anybody to use it without expert assistance. There have been many accidents with HCN even under skilled supervision and although practically all of these can be put down to a momentary carelessness I am not disposed to add to the list by advising the use of HCN by inexperienced operators. This does not mean that I disapprove of HCN fumigation. Hydrogen cyanide is today probably the best general purpose fumigant in the world and the one used in largest amounts (thousands of tons) but it needs expert handling. Many countries have very strict regulations about its use. I will give two examples.

(1) In U. K. fumigation of buildings can only be undertaken if two skilled operators are in charge; one of them must have had at least 18 months previous continual practice and the other not less than six months. The local police and Public Health Authorities must be given 48 hours notice of fumigation.

(2) In Germany some of the regulation are even stricter because a fumigator may lose his licence if, for a period, he has not done any fumigation.

In both countries these regulations are devised to prevent accidents, in fumigation carried out by specially trained personnel.

Although HCN will not be used in most areas for fumigation of grain or of stores it is advisable that some knowledge of the forms in which it is available should be provided. The information given below is not by any means all that is required to enable fumigation to be carried out and this is intentional. It may also be added that such information as has been published in India is not all entirely accurate.

The original method of generating HCN from sodium cyanide and sulphuric acid in a pot is still largely used in many countries. Its advantage is economy and the disadvantages are that it is a troublesome and rather more dangerous technique than modern methods. In this Pot Method, as it is called, the specification of quality of chemical used is most important and so is the ratio in which they are used. The sodium cyanide must be not less than 96 per cent. purity and the sulphuric must be of specific gravity 1.83 (equivalent to 66° Beaume). To obtain the maximum efficiency the ratio should be:—

Sodium cyanide	1 oz. (by wt.)
Sulphuric acid	1½ fluid oz. (2½ oz. by wt.)
Water	2 fluid oz. (2 oz. by wt.)

Potassium cyanide should not be used as it is less efficient, more expensive, and requires an alteration in the ratios.

The modern method involves the use of liquid hydrogen cyanide in gas cylinders and with the proper equipment this is a neat and simple procedure not involving any exposure of operator to the gas. An alternative form is liquid HCN absorbed on kieselguhr, gypsum, fibre discs, etc., and packed in tins of various sizes. A tin must be wholly used once opened and the weight given on the label is the weight of HCN, not of the gross contents. This form is known as "Zyklon" and is prepared commercially with the addition of a lachrymator claimed to be an aid in detection of HCN.

Besides these two modern forms there are a number of dusts which yield HCN when exposed to the air by reaction with moisture in the atmosphere. These are—

Name	Origin	Approximate HCN content by wt.
Calcid	Germany	50%
Cyanogas	U. S. A	25%
Cymag	U. K.	20%

The rate of HCN evolution decreases with the content. "Calcid" can be used for general fumigation as an alternative to liquid HCN or "Zyklon" but the other two are used mainly for specialised work like glasshouse fumigation (very low dosages) and for gassing of rodent burrows. The application to rat holes is dealt with in Chapter XV (p. 43).

Hydrogen cyanide is a colourless liquid of specific gravity about 0.7 (lighter than water) and a boiling point of 26°C (79°F). It would, therefore, evaporate rapidly in Indian conditions and even in temperate climates, so it must be kept in pressure-resisting containers (gas cylinders). It has a faint almond smell but there is much variation in individual sensitivity—some people cannot detect the smell at all. Also, and this is important for anybody using it, the smell may be noticed at first but the nose becomes insensitive very quickly and one is not aware that the atmosphere is getting more dangerous. HCN gas is inflammable at concentrations over 7 per cent. by volume but this greatly exceeds the dosage used, so there is no fire hazard of any consequence in fumigation with HCN. 1 per cent. by volume is equivalent to 12 oz./1000 cubic feet. On the other hand HCN is so toxic to mammals that at 1 per cent. concentration one deep breath could be fatal. An exposure of 30 minutes to 0.2 oz. per 1000 cubic feet (0.017 per cent.) is dangerous.

Carbon bisulphide (CS₂).—This is probably the most widely used fumigant for grain in normal times. The risk of fire is so great, however, that its use is discouraged by insurance companies and during wartime the Ministry of War Transport will not permit its transport by sea. Even in peace-time many countries had stringent shipping regulations. That it is not available need not worry any one because I should be very reluctant to advise the general use of carbon bisulphide in view of this fire hazard and I do not think any Province or State would be likely to adopt it widely.

Pure carbon bisulphide is a colourless sweet smelling liquid. The commercial product is usually yellow and has an unpleasant smell due to impurities. The specific gravity is 1.26. It is heavier than water—12.6 lbs. to the gallon.

The boiling point is 46°C (115°F.) so it can just be kept in drums but care is needed in hot weather or the drums may burst. It is more toxic to man than is usually realised because the effects are not quite so startling as with HCN. Where it is used in factories for various purposes there are usually strict regulations to prevent employees getting injured by breathing the highly poisonous vapour. But the biggest danger is that of fire. The inflammable range of the vapour is from 1 per cent. to over 50 per cent. and the dosage used gives an explosive mixture. Also it ignites at a very low temperature; warm steam pipes have been known to cause an explosion.

The vapour is 2.6 times as heavy as air and its penetrating powers into grain are remarkable when the liquid is applied at the top of a bin and the vapour is allowed to diffuse downwards. Absorption by grain is low. The liquid damages grain.

Ethylene oxide is a comparatively new fumigant. About 16 years ago it was discovered in U.S.A. during a comprehensive search for a fumigant amongst organic chemicals. It is a colourless liquid with a boiling point of only 11°C (52°F) so it must be packed in pressure containers like HCN. This is one disadvantage and the next is a degree of inflammability of the same order as CS_2 . The vapour is inflammable between 3 per cent. and 80 per cent. by volume. The dosage used is about 3 lbs. per 1,000 cubic feet which is just about the lower limit. It does not, therefore, offer much advantage over carbon bisulphide in practice and the use of gas cylinders involves more difficulty in application of measured amounts.

It is nevertheless an excellent fumigant and is used on a fairly large scale in U.S.A., U.K., and Germany, especially for stored products like cereals and dried fruits. As marketed commercially it usually contains 10 per cent. of carbon dioxide which assists the emptying of the cylinder by providing steady pressure.

In order to overcome the fire hazard a mixture of 90 per cent. carbon dioxide and 10 per cent. ethylene oxide has also been produced on a commercial scale but this is very expensive as the fumigation effect is chiefly due to the ethylene oxide. Ethylene oxide is also used along with solid carbon dioxide to reduce the fire hazard.

The gas is poisonous and although the effects are not sudden at low dosages care should be taken not to breathe the vapour—just as with carbon bisulphide. It affects the germination of cereals which is a serious drawback with seed grain. Incidentally this is one of the fumigants which has a delayed effect on insects—the ultimate kill is higher than at first observed.

Methyl bromide is another comparatively new fumigant first reported in 1931 by a French Government entomologist for this purpose. It was extensively used as a fire extinguisher and this led to the idea that it might be used to reduce the fire hazard with ethylene oxide. The results of mixtures were so unexpectedly good against insects that methyl bromide was tried alone and was found to be more effective than ethylene oxide. Here was something good at last—and non-inflammable.

Methyl bromide is a colourless liquid with a boiling point of 4.5°C (41°F) so it is even more volatile than ethylene oxide. It is very heavy, one gallon weighing 17.3 lbs. and the dosage used is only about 1.2 lbs. per 1,000 cubic feet. The vapour is very heavy also. Being much heavier than air penetration of grain in bins is excellent and absorption is low except by flour (large surface). It can also be used safely on plants.

We seem to have got near our ideal here, but we have not yet considered toxicity to man, and here is a difficulty. Although not rapidly fatal like HCN the vapour is definitely dangerous to inhale. The odour is very slight and one can be in a dangerous concentration without realising it. Also the effects are not immediately noticed and it may be 24—48 hours before the patient feels ill. He may then become so ill that he dies. That is a serious drawback under Indian conditions.

Where experienced fumigators (who are completely familiar with the job and the fumigant) take all the necessary precautions methyl bromide is an excellent fumigant, but that is also true of HCN. I am very doubtful if methyl bromide could be recommended for general use. I have already said that the dosage is low—2 lbs./1,000 cubic feet is less than 1 per cent. by volume. Against this we have a concentration of 0.2 per cent. reported as dangerous within 30 minutes and also symptoms on animals exposed for long periods to as little as 0.005 per cent.

With this delayed action on humans it is not surprising that insects suffer in the same way. Having finished a fumigation with methyl bromide one may find many of the insects apparently unharmed and as active as before—but all doomed to die shortly.

Ethylene dichloride: I have deliberately taken you through the historical development of the above three fumigants to show that definite progress has been made. In the meantime I want to go back a little to the time before ethylene oxide was discovered and when many possible fumigants were being studied by the U.S.A. Department of Agriculture. Of these ethylene dichloride looked promising.

It is another colourless liquid with a smell rather similar to chloroform. It is a heavy liquid weighing 12.5 lbs. to the gallon and does not mix with water. The boiling point is rather high, 84°C (183°F), and this fumigant is not so effective as those mentioned above unless considerably heavier dosages are used. It is not quite non-inflammable although difficult to ignite. The vapour in air is inflammable between 6 per cent. and 16 per cent. by volume. With this narrow range the fire risk is very small. Nevertheless the American insurance companies demanded a non-inflammable fumigant in order that farm storage being fumigated should continue to be covered by their fire policies. The U. S. A. Department of Agriculture was able to oblige by producing a mixture of 75 per cent. ethylene dichloride and 25 per cent. carbon tetrachloride. This was done at some expense because the carbon tetrachloride contributes little to the insecticidal value and the dosage of the mixture had to be increased again. This fumigant was produced specially for grain in farm premises and to be used by comparatively unskilled operators, and I have recommended it as on the whole the most suitable of these available for use in India. The U. S. A. Department of Agriculture states that it does not damage grain at any concentration no matter how large the dosage or the exposure period.

Before studying the mixture we must note the properties of carbon tetrachloride. Boiling point is 77°C (170°F) and it weighs 16 lbs. to the gallon. The mixture will, therefore, have a boiling point of about 75°C and will weigh 13.4 lbs. to the gallon. It is non-inflammable and its toxicity is not great towards man. Nevertheless it must be treated with respect. Exposure for prolonged periods or to high concentrations is dangerous and must be avoided.

I shall deal with practical application in the next chapter. There are a few other fumigants which I should mention here.

Chloropicrin: This is a colourless or slightly yellow, heavy non-inflammable liquid, weighing 17 lbs. to the gallon. The chief characteristic is its highly lachrymatory effect which is some safeguard against this rather poisonous gas. (It was used in the last war). The boiling point is high at 112°C (234°F) i.e., above that of water, so that one would expect two things; rather slow action and difficulty in ventilation. Both occur. Chloropicrin clings tenaciously to fumigated grain and can seriously effect the germination if dose is high or exposure prolonged. Although it is a useful fumigant I should not be happy about its general application in India. It is not to be ignored that splashes of the liquid on the skin can cause blisters and there are many bare feet round grain stores in India.

Methyl formate: Without going into all the details it may be said this fumigant generally resembles ethylene oxide but larger doses are needed and it is rather more expensive. There was keen competition between these two

fumigants in Germany ten years ago when they started installing gear for circulating fumigants through large silos or elevators. The fire hazard and explosion risk are both considerable in spite of the comparatively narrow inflammable limits of the vapour in air (6 per cent.—20 per cent.).

Ethyl formate: Similar to methyl formate but with a higher boiling point this fumigant is less effective. It is used in Australia for dried fruits but results are not entirely satisfactory.

Sulphur Dioxide (SO₂) is probably the oldest fumigant having been used by the Chinese and also by the Greeks thousands of years ago. It is generated by burning sulphur and 1 lb. of sulphur will produce two pounds of SO₂ gas which is an extremely irritating vapour. It is highly toxic to insects but its diffusion is poor, it is very corrosive to metals, and it damages grain and flour. It can be used in empty stores at the rate of 3 lbs. of sulphur per thousand cubic feet where fumigation is practicable, but the premises must be well sealed. The temperature should be high and the exposure period should be at least 48 hours and longer if possible. There is always a fire-hazard in burning sulphur.

Carbon dioxide (CO₂): This is a natural product of respiration and an increase in CO₂ content of the atmosphere stimulates respiration of insects as well as humans. It is, therefore, used with some fumigants to reduce the dosage of the more expensive fumigant as well as to reduce the fire risk. Used alone it acts chiefly as a narcotic rendering insects inactive for a long time without killing them. Eventually they will die, as in pit storage of damp grain, the oxygen being replaced by carbon dioxide. Used alone as a fumigant carbon dioxide has never given sufficiently good results to justify its recommendation.

Paradichlorobenzene, (P.D.C.B.) is a white crystalline solid with a not unpleasant smell. It is volatile and disappears gradually on exposure. Well known in the wool and fur trades as a preventive of attack by clothes moth and "woolly bear" this fumigant gives excellent results with seed grain. It should not be used as the other fumigants to treat infested grain but should be used prevent insect attack. The vapour from 1 lb. of P.D.C.B. will saturate 2,000 cubic feet of air in an enclosed space so that the small amount of 2 lbs. should provide an adequate reserve in a 1,000 maund bin of grain. It should be added to the bin with the grain, 1/2 lb. scattered over the surface after each 250 maunds, and the container must then be sealed.

This is a very cheap simple and effective method of preventing insect damage to seed grain whose value can be depreciated to a much greater extent than the amount of damage apparent because of the tendency of grain insects to attack the germ. P.D.C.B. must never be used on grain intended for human or animal food. It does no damage to the grain but imparts the flavour of P.D.C.B. and thus renders it inedible. If such grain is fed to cattle or hens the milk, meat and eggs produced will also be tainted.

This is not any means a complete review of fumigants, and is intended only to provide some idea of the general properties of these in most common use. A new fumigant at present under test shows promise of being most useful for grain fumigation in India. Its chemical name is trichloroacetonitrile (abbreviated T.C.A.N.). It is a non-inflammable heavy liquid with an efficiency similar to ethylene oxide. It is lachrymatory and exposure to dangerous concentrations is unlikely to occur. Further information will be provided when preliminary tests have been completed and when supplies become available.

CHAPTER XII

PRACTICAL APPLICATION OF FUMIGATION

In the last two chapters I reviewed the principles of fumigation and the common fumigants, so that the lay reader might realise what fumigation involves. To become a fully qualified fumigator would need about two years of continuous practical experience under specialists. By that time one would

realise how much is to be learned. But the first step is to get some idea of what one is up against. I think it will be agreed that it would be unwise to rush into fumigation as a cure for all troubles. The amount of fumigation to be done, and the kinds of fumigation, I propose to limit very strictly.

The one type of fumigation that I feel I can recommend widely is the use of ethylene dichloride/carbon tetrachloride mixture for bulk grain in modern bins with bottom trap for discharge, and for empty bags in small bins. That may sound very little but even this limited field will provide much useful practice in assessing dosages and effective kill so that later activities may be extended.

Fumigation of Bags

This is the simplest job and can be done on a small scale so let us begin modestly. Used bags are one of the chief ways of infestation spreading. We have already discussed other treatments but it may often be possible to fumigate. One method used by the Ministry of Food in U. K. is to crumple up 19 bags into one and stack them over the floor of a small room, then fumigate with cyanide or other gases. Heat treatment is also used.

A very simple treatment can be carried out with ethylene dichloride by crumpling up 20 bags into a dust bin or other metal box with a good fitting top. Sprinkle the liquid over the top bag, replace the lid, seal and leave for 2 days. The dosage is easy to remember, 1 fluid oz. per 2 cubic feet. Check results with insects in a test-tube in the bin and modify according to local conditions till you get the lowest dose for complete kill. Note the temperature because larger doses will be needed in cold weather. Spread the bags out to ventilate after treatment then stack in a store kept for *clean bags*.

For larger scale operations the small fumigation chamber I mentioned in Chapter V can be used. Let us say it is 10 ft. x 10 ft. x 8 ft.* with smooth plastered walls and gas-tight roof (flat). This chamber should be placed in the centre of the 20 ft. square space. It should have a window in each of three walls and a door in the fourth. Design the door to fit closely on the lines of a refrigerator door and with the same type of handle one at 2 ft. and the other at 5 ft. (7 ft. door). The windows should open from outside but may be padlocked for security. Round the walls inside build 2 ft. wide slatted shelves at 2' 8" and 5' 4" and run another pair down the middle. These can be made strong enough to hold bags of grain, and can be fitted loose for removal if necessary.

Do not use crumpled bundles but stack rolls of 20 bags on end on the shelves and on the floor. This Chamber will hold about 1200 bags—60 rolls of 20 bags each. The same dosage is just over 3 gallons and this can be sprayed from outside through a metal Y piece with two spray nozzles fitted through the door. Before you do this, however, make sure that you need the larger scale. If you need to do only 100 bags every day it is better to use 5 bins than to use the chamber process once a fortnight. That is the sort of thing that must be worked out. There is a loss of space in a chamber because one cannot pack it full or proper penetration does not occur. All precautions detailed below for bulk grain fumigation must be followed.

It may be practicable to carry out fumigation of bags in a bulk grain bin but that requires some experimental work before it can be advocated so just keep to the simple processes until other definite recommendations are made.

Bulk Grain Fumigation

Let us start off by receiving infested grain, not seriously damaged, say below 1 per cent. by trade method. If we get this in October we could not store it for say three months in Bombay or Madras without serious loss. Load into a bin of 1,000 maunds capacity, stopping before it is quite full. The dosage of the fumigant is 60 lbs. or 4½ gallons for 1,000 maunds. Pour the fumigant on

*This is smaller than that in Chap. V. The size is a matter for local consideration and advice should be obtained from the Food Deptt., before construction is undertaken. Chamber fumigation of bags is relatively expensive.

to the grain as quickly as possible. Fill up with grain to the top, close the lid and seal it. Do not open for at least 48 hours and if you can leave it for a week so much the better. Usually this will be possible.

That is the procedure briefly but let us go into details—it is always the details that matter in fumigation for both efficiency and safety.

First we must have all our preparations made before we start. On the inside of the manhole door fix a label with date and dosage of the fumigant. The dose of $4\frac{1}{2}$ gallons can conveniently be measured into two $2\frac{1}{2}$ -gallon watering cans each fitted preferably with a spout of 3 ft. in length and a very coarse rose. Measure the height of $2\frac{1}{4}$ gallons of water and bore a hole at this level to take a bolt and nut with two washers. (Remember this fumigant is a solvent for paints and it also affects rubber). It is easy to fill quickly each can up to the level of the projecting bolt or other mark.

Now we can start

(1) Apply the fumigant in the early morning, the grain having been loaded the previous day if necessary. Never do this job between 10 a.m. and 5 p.m.—the loss of fumigant will be greater and there is more risk to the operators.

(2) Fill the 2 applicators in the open air and take them to the open manhole beside which you have at least one bag of grain ready to top up the bin.

(3) Starting together and standing on the wind-ward side the two men pour the liquid into the bin, the long spouts helping to spread the liquid over the surface of the grain.

(4) Immediately they finish add the spare bag of grain to top up. Close the manhole and seal it with mud.

(5) In opening up have the manhole open for several hours before beginning to unload from the bottom trap. Remember you put 60 lbs. of fumigant in and a lot of it will still be there. This process should not be used for top unloading bins unless great care is taken and coolies should not enter these bins without a rope belt as a safeguard.

(6) If bagging straight from the bin go slow until you see if there is much vapour about. If there is you must take care that coolies are not unduly exposed. The effect of the vapour is rather like that of chloroform—anaesthetic. You will, therefore, not open half a dozen of these bins at once—but only one at a time.

(7) If anybody complains or seems to be affected get him away from the site to an open space where he can rest in the fresh air. Take no risks. It is never worthwhile.

This operation may seem laborious and dangerous but it is neither. It is the simplest type of fumigation.

I have not mentioned gas-masks because I have tried to confine the work, to conditions where they should not be essential. They are extremely uncomfortable in hot weather. If you have A.R.P. respirators they will be of some value, but *not inside the bin*. There a rope belt is needed. The bins will not empty completely and any coolie going in should await until there has been some through ventilation from the trap below to clear the air, and must wear a rope. I do not say he needs it (usually he will not) but if he should not be able to get out and you have no rope there will be trouble.

The dosage I have given is that recommended for bins in U.S.A. at a temperature of over 70°F and less may suffice in India. *Trogoderma granaria* is more resistant than other grain insects. We hope to do some tests in Delhi to check this and shall advise if the dose can be reduced. The supplies of fumigant expected are limited and I am not prepared therefore to issue this fumigant everywhere until we have had some experience under these conditions. I do not think there is anything to worry about but I propose to practice what I have been preaching—"Take no risks". In the meantime there is plenty of work to be done on general hygiene which in any case should precede more technical developments.

Now let us look at the godown which we designed for fumigation. It holds 3,000 bags—7,500 maunds so the dosage would be $7.5 \times 60 = 450$ lbs. = 33

gallons of fumigant. But there is also a lot of air space above and around the stacks so allowance must be made for this and the dose needed is actually over 300 lbs. say 60 gallons. That is rather a lot to apply. I am not going to give details because I think the job is technically too difficult until one has had some experience of simpler applications. We should have to seal all windows with gummed paper (on the outside) and have the sealing all ready for the doors. Then we should have to devise a rapid and effective method of applying 15 gallons to the top of each stack, giving time for the operators to get out. Here gas-masks and a large gang are essential. A number of dummy training operations is also a necessary preliminary to actual fumigation. The liquid can be pumped in from outside the sealed building and this is much safer, but the fumigant affects rubber so don't jump to conclusions. Let us leave it at that.

I really should have dealt with fumigation of empty buildings first. But I doubt if it is economical with this fumigant. For suitable buildings HCN is highly effective but too dangerous. We may have to come to that at a later stage but I am hopeful that we shall find a safer alternative for general use.

That leaves us at present with sulphur which frankly I do not like much because of the fire risk. With a room 20 ft. x 20 ft. x 70 ft. the dosage at 3 lbs. per 1,000 cubic ft. is $28 \times 3 = 84$ lbs. This should be laid out in not less than six trays each of 14 lbs.. The sulphur should be in a conical mound and the trays are better to be a few feet off the ground if possible. The sulphur is ignited with the aid of a little methylated spirit—six operators must act together and again a little practice is wanted. Try in a room or better outside with a few oz. of sulphur till you get the trick. It is useless if only half the trays burn and one has to get out because of the fumes.

The sealing must be as before and when all are out the doors are sealed in the same way. A notice must be posted on both doors—Warning of gas—and these must be locked. Open up after 48 hours—top windows from outside first and doors half an hour later. Ventilate till free of SO₂ odour. Sulphur dioxide has one merit. It is useful for practising fumigation without much risk if one is careful about fire.

I must warn you that you cannot fumigate even a suitable building unless you are sure that in ventilating you are not going to alarm the neighbourhood. The adjoining property must always be a primary consideration.

I have given a dosage of 3 lbs. sulphur not because it is necessarily enough but because there is difficulty in burning larger amounts in a confined space. As the sulphur burns it consumes oxygen so that the oxygen available for this reaction steadily decreases. The amount of oxygen in 1,000 cubic feet of air is theoretically capable of burning about 18 lbs. of sulphur but this can never happen. If you use more than 3 lbs. an unburned residue of sulphur will result. The removal of oxygen may help the fumigation but with the combination of a gradual increase of sulphur dioxide closure of insect spiracles (respiratory tubes) and a state of suspended animation is also likely to result.

This leads us naturally to the question of superheating. As practised in India it rather resembles the burning of sulphur and attempts have been made to combine the two. With charcoal the difficulty is rather greater than with sulphur because only about $6\frac{1}{2}$ lbs. of carbon (coal) can theoretically be burned in 1,000 cubic feet of air. Carbon dioxide is produced instead of sulphur dioxide and it is doubtful if as much as 1 seer of carbon could be burned in practice per 1,000 cubic feet—that is with the room sealed up properly. Therefore you must have a draught when using the 7 seers of charcoal or coal advised per 1,000 cubic feet.

The purpose is to raise the temperature not only of the air but of the walls and floors above 140°F when all insect life is destroyed rapidly. It is naturally easiest to carry out in the hot weather when the roof may already be that temperature or more if it is of metal. I have no personal experience of the practical value in India but I suggest that those who are dealing with premises

not fit for proper fumigation but fairly easy to close up should look at this possibility before the new crop comes in. Take a badly infested store and use too many braziers rather than too few. Avoid buildings with wooden floors and be careful of fire at all times. Get your braziers going well—No smoking—before you place them. At the end of the period rake them out gently to remove ash and weigh again to see how much carbon (coal or charcoal) has been consumed. I also recommend those of you who can get one to put a "maximum" thermometer in the store. Wrap it up in a gunny bag and put it in the farthest corner from the braziers. Note the temperature at the beginning and see what is the maximum recorded. Do not exclude fresh air until you achieve 150°F in the room. Then seal for 48 hours after adding the last charge of charcoal. This is not such a simple operation as it seems and I commend it also as an exercise in practical control.

Some insects (larvae and adults) can be placed in the store in test-tubes wrapped in a piece of gunny to see if they are all killed. This can be done with sulphur fumigation also but then one must use muslin or wire gauze over the end of the tube.

Remember that it is difficult to generalise from the result in one building. Every fumigation is a separate and specific problem. One can learn a lot, however, by keeping proper records of every fumigation and for this purpose a report of the following standard type should be used.

- | | |
|-----------------------------------|----------------------------|
| 1. Date | 11. Temperature at start |
| 2. Name of store | 12. Time of opening |
| 3. Description | 13. Temperature at opening |
| 4. Cubic capacity | 14. Period of ventilation |
| 5. Contents and their disposition | 15. Weather conditions |
| 6. Fumigant used | 16. Insects involved |
| 7. Dosage per 1,000 c.ft. | 17. Results |
| 8. Amount of fumigant | 18. Observations |
| 9. Method of application | 19. Signature |
| 10. Time of start | |

If everybody keeps such records findings in one place can be correlated with those elsewhere. But the chief value is to yourself. If a job is a failure you have a good chance of finding out why when you have complete records and compare with past results. Need I say that the record must be an accurate one? It must be prepared at the time, and not made up later with a guess at time and temperatures. *That would be worse than no record for it gives an inaccurate statement which may easily lead to wrong conclusions.*

CHAPTER XIII

MISCELLANEOUS INSECT CONTROL MEASURES

Disinfectants like carbolic acid (phenol) or cresols are of little practical value as insecticides. They function as bactericides and they have the disadvantage of tending to impart a taint in grain stored in treated premises. They have some value against mites for which 5 per cent. cresol solution is a standard remedial treatment, but the presence of mites is a sure sign of high moisture content in cereals so that improvement of storage hygiene is necessary.

Where for any reason it is desired to *deodorise* premises the most suitable chemical is chloride of lime (bleaching powder). About 1/2 lb. of chloride of lime (bleaching powder) in 10 gallons of water can be used as a wash or spray on floor or walls. This solution should be handled carefully but it is not dangerous. It will corrode metals so if a bucket pump spray is used it should subsequently be washed out thoroughly with water. Clothing splashed with this spray will be damaged if the solution is not thoroughly washed out. This solution is not an insecticide.

Contact insecticides in the form of sprays have a limited application in cereal stores. Using pyrethrum it is necessary to have from 0.8 per cent. to

1.6 per cent. of total pyrethrins (against 0.1 per cent. in fly sprays) so that cost is high even if pyrethrum were easily available in quantity. Application should be made from a spray-gun operated by compressed air to give a very fine spray which remains suspended in the air. Used in this way sprays have given good results against various moths infesting stored products. It is not possible however to reach the more resistant beetles which are concealed in grain.

There is considerable promise in two new insecticides "D.D.T." and "666" experimental quantities of which have been received for tests. Work already done in U. K. and in India supports the view that these may ultimately be more important than fumigation in the treatment of premises. Formulations for sprays and dusts have first to be devised before these can be offered for large scale tests.

Mainly because of the promise offered by these new synthetic products I have not considered it necessary to discuss in any detail what are known as "Inert Dusts". These are fine powders, chemically inactive, but with considerable insecticidal power, believed to be largely physical in mechanism. The essentials for active dusts are hardness, sharpness and small size of particles. Even a very effective dust can be made quite valueless by poor grinding and it is necessary that the majority of the particles should be less than 1/200 millimetre in diameter.

The best known of such dusts is probably *Katelsousse* (Arabic, *Katel* = kill and *sousse* = grain insect) a discovery of the Egyptian Department of Agriculture. Thousands of tons are used in Egypt every year. It is a mixture of finely ground rock phosphate and sulphur. Applied at 1 per cent. by weight on the grain and mixed thoroughly it has very marked protective powers. It is not intended as a treatment for damaged grain but as a preventive and much misunderstanding has arisen from failure to appreciate this point. In Egypt grain is usually stored in heaps in the open air so it is comparatively easy to mix with *Katelsousse* using wooden shovels. The procedure becomes rather expensive for bagged grain owing to handling charges. To mix adequately during filling of bulk bins is feasible but not so simple as it seems.

Quite useful results have been obtained by laying a 6" wide band of *Katelsousse* round the base of bag stacks. This traps large numbers of grain weevils and rice weevils, but is naturally more effective against the former which do not have the ability to fly. Dusting over stacks of bagged grain has also been tried and gives some measures of success. It is not a really adequate safeguard, however, compared with mixing with the grain.

There are various other dusts of a similar type manufactured in U. K. but development of this procedure is not attractive under modern conditions of bulk handling, nor is it generally necessary, because other control measures are available in the way of fumigation, etc.

To give some idea of the efficiency of *Katelsousse* tests have been carried out to measure the rate of kill of grain weevils introduced to treated grain. About 14-21 days are needed to give a complete kill so the action is a comparatively slow one and some egg laying occurs in the meantime. The larvae inside the grain are of course protected until they emerge as adults. Nevertheless practical efficiency on a large scale has been indubitably proved under conditions of high humidity when inert dusts are least effective. This test explains why treatment is necessary to prevent infestation and why it is of little value if more than a very slight infestation exists previously.

In comparison with these results laboratory tests with "D.D.T." and "666" have shown a complete kill of grain weevil in 6-10 days with only 0.0006 per cent. of the active chemicals present in wheat containing 14 per cent. moisture at 80°F. A considerable amount of further research work must be carried out before this procedure can be generally recommended.

Heat treatment of stores has already been discussed and can be applied to grain by exposing in thin layers to the tropical sun for 4 or 5 hours on a

concrete, brick or stone plinth. A soil flooring is less effective. Grain should be only a few inches in depth and should be turned over at intervals by raking. This process is known to every cultivator and is simple on the small scale but offers practical difficulty when one is handling thousands of tons. The process also reduces the moisture content of the grain and improves it for storage purposes.

Plant is manufactured for this heat treatment, not so much to kill insects as to reduce moisture content. It is used commonly for maize which often has too high a moisture content for storage or shipping. It has been necessitated recently in U. K. for the wheat crop which is usually too high in moisture content for storing unless mixed with drier imported grain not available today to the normal extent. The drying process also destroys insect life and can be used for this purpose. The general principle is to pass a current of hot air at about 160°F up a column through which the grain is descending. Careful control of temperature is necessary to avoid damaging the grain. Arrangements for bulk handling are necessary and it appears unlikely that such plant could be economically used under present conditions in India.

In concluding this discussion of insect control measures, I think it is necessary to give a caution against the tendency to draw conclusions from experiments, either in the laboratory or in the field, which have not been designed in such a way as to eliminate or at least to minimise factors not common to all the tests under consideration. I have mentioned in Chapter X some of the difficulties encountered in estimating the value of fumigants. These and many more are experienced in carrying out any control experiments; particularly on the practical scale, and it is essential to have the proposed experimental layout examined beforehand in order to ascertain if it will give results of any value. It is a waste of time and effort if analysis of the results shows that some essential factor has not been considered and that no valid conclusion can be drawn.

CHAPTER XIV

RODENTS AND RAT-PROOFING

I do not propose a general rat extermination campaign of the kind which has been so successfully carried out in the United Kingdom by the joint efforts of the Ministries of Food and of Agriculture, with the cooperation of local authorities; but I do want to emphasise that because such action is not practicable in India at present our problem is not insoluble. We may not appreciably reduce the rat population at first but we must put a stop to conditions which lead to an increase in the number of rodents. Many sites now used for grain storage provide the essentials—cover, food and water—for rats. Given these, the rat population multiplies very quickly. Deprived of these, surviving rodents go elsewhere and everything that can be done to make life more difficult for them is of value in reducing this menace to our food and our health.

It must be borne in mind however that sporadic efforts leading to the destruction of a few hundred or a few thousand rats are of little value in reducing the rat population because replacement by breeding is very rapid. Even if one achieves the rarity of 100 per cent. extermination the area will soon be repopulated from surrounding districts. The Rat Week, once so popular in England, has now been completely discredited as an effective control measure. To be of any use operations must be carried out for 52 weeks in the year and in each successive week the efforts must be more thorough because the residual rats having escaped the first "blitz" will be well aware of the skill needed to evade death. It is difficult to over-rate the intelligence of rats which has enabled them to survive for thousands of years in close proximity to man and in direct competition with man for his food.

I would also warn against the "subsidy" method by which rewards are offered for each rat brought in. It has never given really successful results. If the method is to be of any use the number of rats obtained should increase

to a maximum at a rate depending on the number of people engaged in operations and should then show a steady decline. Usually the reward offered is not enough to yield results of practical value and if it were the encouragement to do a little private breeding would become too tempting. In either case the usual result is that the maximum return of dead rats is sustained indefinitely or until the operators decide that there are more profitable methods of earning money.

As grain storage officers have no control over adjacent property all they can do is to eliminate the rat population in the grain stores and ensure that rats from the neighbourhood do not get access to these stores. This is not so difficult as may be imagined although all stores cannot be made rat-proof. Proofing of stores has been dealt with in Cereal Storage Advisory Note No. 1 which is reproduced at the end of this chapter. Other measures are reviewed in Chapter XV including poison baiting, trapping and gassing. With these latter the collaboration of the local Public Health Authorities should be enlisted and the practical experience of sanitary inspectors should be of value in regard to local conditions, types of rats, methods found useful etc.

The various species of rodents with which we are concerned can be divided into two main groups represented by:

(A) House rats—

- (1) *Rattus rattus* (Black rat).
- (2) *Rattus norvegicus* (Brown rat).
- (3) *Mus musculus* (House Mouse).
- (4) *Mus bactrianus* (Persian House Mouse).

(B) Field Rats—

- (5) *Gerbillus* species.
- (6) *Nesokia* species (Mole rats).

House Rats.—Throughout India in urban areas the so called black rat predominates although the brown rat is believed to be increasing in numbers. It may be of interest that of the 50 rats obtained from Delhi Public Health Department for the recent storage training course, at Pusa Institute, every one was *Rattus rattus*. All were caught in cage traps in which *Rattus norvegicus* is considered by U.S.A. Public Health authorities to be more easily caught.

Differentiation between the two species is easy. *Rattus rattus* has a tail longer than body plus head and has large thin translucent ears which are almost hairless. *Rattus norvegicus* has a tail definitely shorter than body plus head and has relatively small thick hairy ears. Colour is of no value since it may vary in *Rattus rattus* from light sand to very dark grey or brown. I have never seen a completely black *Rattus rattus* and *Rattus norvegicus* is frequently grey in colour rather than brown. Full-grown *Rattus norvegicus* is larger than *Rattus rattus*.

The habits differ in an important way for *Rattus rattus* is predominately a climber and will often nest above ground in house and in trees while *Rattus norvegicus* is a burrower and prefers an underground home in drains or sewers which frequently provide useful means of access to food. These rats will not jump more than 30 inches in height so that a 3 ft. wall with a smooth horizontal projection of 8" forms an effective rat-guard. The black rat cannot stretch more than 8" and this is the one likely to attempt to climb the wall.

Except in the North West the common house mouse is widely dispersed throughout India. In the North West its place is taken by the Persian House Mouse. Differentiation is not important, because habits are similar. Mice climb rather better than the black rat but the above rat-guard will stop them.

Field Rats.—These are not so important to us except in rural areas. *Gerbilles* inhabit sandy areas and can jump several yards in distance owing to the exceptional length of the hind legs which readily distinguishes members of this genus, as do the large gazelle-like eyes. The others are types of mole rats and are very destructive to growing crops. These mole rats are heavily built and have very good digging powers. They do not exhibit the intelligence of the house rats. Gassing of burrows around cultivated land should give effective

control if carried out on a sufficiently large scale but that is not the direct concern of grain storage officers. The mole rats include several species of *Nesokia*. All are heavily built with tail shorter than body plus head and rather coarse hair. The Indian Mole Rat (*N. bengalensis*) and the Bandicoot (*N. bandicota*) belong to this genus. They are sometimes rather ferocious in appearance and make a grunting noise when alarmed. The Indian Mole Rat attains a size of 9 inches exclusive of tail and the Bandicoot may be up to 15 inches in length exclusive of tail. It may be mentioned that large specimens of *Rattus norvegicus* found commonly in Calcutta are frequently mistaken for bandicoots.

The *Mongoose* should not be destroyed as it preys on rats and is in some ways better than a cat. Neither can, however, be relied upon to keep grain premises entirely free of rats.

In this chapter I am dealing only with rat-proofing of stores. This is not possible with all the premises used for storing grain at present and other methods are considered in the next chapter. For new construction there is no reason why the building should not be rat-proof from the beginning, even if in congested port areas.

RAT-PROOFING OF GRAIN STORES

There are two ways of preventing rat damage to stored grain. The first is to destroy all the rats in the district and this method has been adopted in U.K. with great success. It is not, however, generally applicable to tropical countries as a short-term policy. The second method is to ensure that the grain stores are so constructed that rats can neither get in or get out. This is by no means so difficult as one might imagine and the general principles are outlined below. Experience in Middle East territories has shown that excellent results can be obtained at very low cost if the problem is tackled intelligently.

The measures are in general very simple and present no difficulties except that of ensuring efficient carrying out of instructions. The chief points are:—

(1) The floor should be concrete, brick, or stone, and a wooden floor over soil should be avoided at all costs. If a bare soil floor must be used the walls of the building should be of stone, brick or concrete, etc., with foundations (including door space) going to a depth of 3 feet. With a soil floor and walls of wood or corrugated iron, rat-proofing is usually impossible, but such walls can be used if the floor is impervious and above ground level, so that the junction of wall and floor can be sealed with cement.

(2) Doors must fit well, no gaps wider than 1/4 inch being permitted. This is the most common fault and one that can be remedied easily. If doors are of wood, rats can gnaw through at the corners, but by fitting tins along the bottom 4 inches of the doors, this can be prevented. The lower end of the tins should pass below the door and be attached to the inside. Old kerosene or cigarette tins can be used for this purpose. Wooden battens forming door steps may be treated similarly.

(3) Window openings should not be less than 3 feet from ground level and the wall below should have a smooth surface unless there is glass, 1/2 inch wire netting or some other rat-proof guard on the window. The importance of clearing any lumber from below open windows must be emphasised as any other proofing will be nullified if this is not done.

(4) Drain-pipes from the roof should be cut away 3 feet above ground level or protected at the open end with 1/2 inch wire netting or expanded metal, etc. Any drainage holes leading from inside the premises through doorsteps or walls should also be treated with wire netting.

(5) Any rat holes already in the building should be sealed with cement containing pieces of broken glass. This cannot be done with a soil floor and it is best to avoid such buildings if rats already exist inside. Otherwise gassing of the holes is required, and this treatment is not suitable for general use by unskilled personnel.

(6) Rat-proofing should be carried out before the grain is introduced, as rodents may also take up quarters amongst the stacked bags. This, however,

is not very important if no water is available inside, as rats can live only a few days in complete absence of water, but even a drip from a tap would be sufficient. It is of course important to ensure that there is no access to rain water in roof gutters, etc., or to sewers.

The above points do not cover all possible contingencies, but are given to show the general lines of operation. Every store presents its own particular problems, and if a single entry is overlooked, the work done is wasted. Obviously some buildings cannot possibly be proofed and these should be used only for temporary storage and as a last resort. It is recognised that throughout India it has been necessary to utilise buildings of all kinds, many of them never intended for cereal storage and totally unsuitable for this purpose. Nevertheless by applying the above principles to all stores which can be made rat-proof considerable progress will be made in reducing the amount of rodent damage.

It may be that the seriousness of rodent damage to cereals is not fully appreciated, especially where large tonnages are being handled over short periods. The following facts should be widely circulated:—

(a) 100 rats without breeding will eat 27 maunds of grain in one year.

(b) Not only the eaten grain is lost, but also that fouled by rats which carry several diseases, and the larger amount which is subsequently lost in handling and transport of torn bags. The U.S.A. Public Health Authorities estimate that losses from rats are 8—10 times the amount actually consumed.

(c) Given a good food supply, rats breed very rapidly. In one year the female rat produces 5 litters each containing about 9 young. These begin to breed within two months of birth and it has been calculated that one pair of rats can produce 800 descendants in one year.

• There are areas where grain is stored outside and here the problem is more difficult but still not insoluble. Such grain should be stacked on a plinth at least three feet above ground and with a slightly domed concrete surface. At the edge of the plinth there should be a rat-guard projecting horizontally or slightly downwards. This rat-guard should be at least 8" in width. It should be made of metal or concrete.

An alternative method is to enclose the area with rat-proof walls which require a foundation of 3 feet to prevent rodents tunnelling below where the stacking surface is not of brick, stone or concrete. Adequate drainage must be provided through rat-proof channels at the base of the walls which if not more than 3 ft. high require the same horizontal rat-guard. A smooth exterior surface is essential. Galvanised iron can be used for this purpose with the top 8" bent out at right angles to the wall. This method is used in Australia for enclosing stacks of bagged grain kept in the open.

CHAPTER XV

RODENT CONTROL MEASURES

This is another subject which has been the subject of many publications and it is not easy to compress all the essential information into a few pages. The information which is given here is mainly restricted to the findings of the Bureau of Animal Population, University of Oxford, which has for some years been carrying out an intensive programme of research on rodent control measures under the auspices of the Agricultural Research Council in England. Their findings have been applied with great success by the Ministry of Agriculture and the Ministry of Food in the United Kingdom during the war, and have been made freely available to the Government of India.

I have already considered rat-proofing which is the simplest and where it is applicable, the best method of preventing rodent attack of stored grain under conditions in India. There are, however, many situations where rat-proofing is not possible or where other measures are required. Trapping, gassing and poison baiting must be considered. It may be necessary, and it is certainly advisable,

to obtain the co-operation of local Public Health Authorities in any such campaign. The officers concerned in the Public Health Departments have considerable local knowledge and experience which it would be foolish to ignore.

Plan of campaign

(a) The following general plan should be adopted:

- (1) Complete survey of infested areas.
- (2) Poison baiting campaign.
- (3) Follow-up treatment with poison baiting, gassing or trapping.
- (4) Regular inspection and maintenance of control.

(b) In the first place it is necessary to study the habits of rats and to make a thorough survey of the sites of infestation. Rats are mostly active at dusk and at night, but their presence can be confirmed by damage to food and food containers, burrows with freshly excavated earth or smooth worn passages, fresh droppings, regular runways, holes gnawed in woodwork, dark body smears on woodwork or flooring, and footprints. By means of these signs you should find the living holes of the rat colonies, their feeding places, and the runways between the two. It is extremely important that as much as possible be ascertained about the size and complete distribution of rat colonies before control operations are begun.

(c) When it has been discovered exactly where the rats are living, running and feeding, the strategy of control is to kill them, either in their holes by poison baiting or gassing or on the runways between their holes and their normal food supply by poison baiting or trapping.

(d) You should try to organize the campaign simultaneously at all the infested points, otherwise much trouble may be experienced in getting rid of the final remnants. The procedure adopted should follow the lines laid down below.

Trapping

Rats.—Break-back treadle rat traps are an inefficient means of tackling large infestations which are best dealt with by poison baiting; but they are often valuable for clearing up small infestations remaining after poison campaigns. They can also be used where the danger of corpse smell is considered too great for poison baiting. The following method should be used:—

(a) The traps should be placed at the holes or with the treadle at right angles across the runways, preferably where these are close to a wall or other object.

(b) Put down the traps baited, but do not set them until the rats have begun to visit and take the baits. Then set them all at once. Baits can be fish, bread crust, or in hot weather tomato, cucumber, etc. Traps should be visited daily until they catch no more rats.

(c) If there is any danger of accidentally trapping other animals or birds, the trap may be laid under a board sloping against the wall. In adopting this device, allowance must be made for a delay of some days before the rats start to run under the boards.

(d) Cage traps can be used on the same principle, setting once food is being taken regularly. Only cage traps which conform to the specifications laid down by the Director of the Haffkine Institute, Bombay, should be used.

Mice.—(a) Break-back traps are the best means of dealing with house mouse infestations, the essential being to use a large number at once. For any reasonably large infestation of house mice, lay twenty to fifty traps, if possible of the type with a flat treadle on to which the mice can run.

(b) There is no need to prebait the traps for mice. They can be set and baited on the first night. The best bait is flour, *atta* or flaked cereals scattered over the treadle. If the traps have wire prongs instead of a treadle, make one by fixing a stale crust on to the prongs.

(c) The traps should be set at right angles to, and against the walls, sacks, or other places where the mice are running, not out in the open. Mice have often a very small radius of movement from their nests. Sometimes only a

few feet, so that traps should be closely spaced, or moved about to cover the whole area thoroughly. They should be visited daily until they catch no more mice.

GASSING

(a) Cyanide gassing is a valuable aid in cleaning up *outside* infestations. It is highly dangerous to gas inside any building. The use of cyanide dust in outside rat holes is quite safe if reasonable precautions are taken. It is only efficient in solid ground, not in loose rubbish tips, etc., and gassing should never be carried out in rainy weather or in water-logged ground.

(b) The materials available are "Cyanogas" and "Cymag". No pump is required; instead, the method of "spooning" the powder should be used. Block in all rat holes. Next day put a heaped teaspoonful of this powder into the "spoon" (a small tin wired on to a stick), and tip it out in a heap about 1 foot down each reopened rat hole. Then block the entrance with turf, a stone covered with earth, or with mud. Tread in firmly but be careful not to cover the powder with earth in doing so.

(c) The powder produces a small zone of lethal concentration of hydrogen cyanide gas which kills most of the rats as they are digging their way out.

(d) A certain number of holes may be reopened by the rats, and the process should then be repeated on the re-opened holes until all the rats are killed.

(e) Gassing is especially valuable for cleaning up rat colonies that have become difficult to bait but, as emphasized above, it is only applicable to outside sites such as hedge-banks, solid refuse dumps, etc.

(f) Both "Cyanogas" and "Cymag" produce hydrogen cyanide when exposed to atmospheric moisture and their use must be restricted to operators who appreciate this. It must not be left to coolie labour. The necessary precautions are—

(1) Place the tin on the ground before opening to avoid spillage, and avert the head from the open tin.

(2) Having removed one heaped teaspoonful of dust replace the lid at once.

(3) Transfer the dust to another "spoon" for application rather than directly into the hole so that the applicator used in the rat holes is not introduced into the tin. It may get dirty, wet or muddy.

(4) Do not operate during rain and see that dust is not spilled on clothing.

(5) After use see that the lid of the "Cyanogas" or "Cymag" tin is replaced properly and return the tin to a *dry* ventilated store which must be kept locked. Use only directly from original container.

(6) Wash the hands thoroughly even if no contamination is known to have occurred.

NOTE.—"Cyanogas" (5 lb. tins) is supplied by Messrs. Shaw Wallace & Co., Head Office Calcutta. "Cymag" (7 lb. tins) is supplied by Imperial Chemical Industries (India) Ltd. Head Office Calcutta. Only the small size tins should be ordered.

Poison Baiting

For this we require a bait base and a poison. The bait base may be grain, *atta*, or gram flour for dry baits. With *atta* or gram flour 10 per cent. sugar increases the attractiveness of the bait base. A useful moist bait is made from dry sausage rusk which resembles coarsely ground biscuit and will absorb about half its weight of water which is added to give the moist bait. Another wet bait base found useful is made from stale bread soaked in water, after which the excess water is decanted and the residual porridge used as a bait base.

Three poisons are recommended in their order of efficiency:—

(1) *Zinc phosphide* a black powder used at 5 per cent. by weight on all baits.

(2) *Arsenic*.—(Arsenious oxide)—a white or grey powder used at 10 per cent. by weight on wet baits and at 15 per cent. on dry baits.

(3) *Barium carbonate* a white gritty powder used at 20 per cent. on wet baits only.

Zinc phosphide is the preferred poison but, as will be seen below, an alternative must always be available, and arsenic is preferable to barium carbonate which is the least reliable of the three baits. The arsenic or barium carbonate used must be finely ground or its efficiency will be low. Arsenic and barium

carbonate are available in India from indigenous sources and supplies of zinc phosphide have been released by United Kingdom authorities for the Government of India. Application for zinc phosphide should be made to the Department of Food.

For a dry bait of zinc phosphide and whole grain a trace of vegetable oil may with advantage be mixed with the cereal before the zinc phosphide. This makes the base more attractive to rats and aids adherence of the poison to the grains. Dry baits will keep for a considerable time but moist baits must be freshly made and it is preferable not to accumulate stocks of made-up poison bait.

Pre-baiting method of poisoning.—The basis of this method is the overcoming of the initial suspicion of rodents to anything new by supplying unpoisoned food until it is eaten freely and the rats are attracted to regular feeding points. It may be difficult to achieve this in grain stores.

For a campaign two separate bait bases and two poisons are needed. After prebaiting the only change made in the bait is addition of the poison. If a complete kill is not obtained this will be shown by a take of the second bait base laid subsequently. Build up confidence again and then add the second poison. Survivors from the first effort may be prejudiced against either the base or the poison so it is necessary to change both for the follow-up treatment.

Poisoning is by far the quickest and most effective method of killing rats, provided it is properly done. By recent improvements in baiting methods it is usually possible to get a kill of from 80—100 per cent. on the first treatment, and a similar success with follow-up treatments. Below is a summary of how to organise and carry out a poison baiting campaign—

(a) Estimate from your survey the number of bait points needed, and from this the amount of supplies and equipment that will have to be used.

(b) Decide on the baiting sequence to be adopted. Usually this will be moist sausage rusk and zinc phosphide followed (if there are any survivors) by gram flour or *atta* and arsenic. If there is a risk of rat corpse smell, start with sausage rusk and arsenic, instead of zinc phosphide.

(c) Rats are suspicious of new things, and they must be attracted to eat plain food (the "bait base") placed at fixed visiting points. This is called pre-baiting. Prebaiting draws the rats into the baiting points, and overcomes their first suspicion.

(d) Place one dessert spoonful of the plain bait (moist sausage rusk) in all occupied holes or other safe places, on the first and third days.

(e) On the fifth day place one or two spoonfuls of the bait base mixed with the poison, using the bait formula recommended.

Container baiting

(f) Where there is danger to human beings, animals or birds, prebait and poison must be placed in boxes or pipes.

(g) These containers are placed along rat runs, prebaited and left for one to two weeks or until rats are using them all.

(h) Four dessert spoonfuls of prebait are placed in each container every day for five days, and then eight spoonfuls of poison bait on the sixth day.

Follow-up treatment

(i) If the first treatment does not kill all the rats, they should be prebaited with one of the other bait bases, followed by one of the other poisons. If this in turn leaves any survivors a third bait or trapping or (for outside infestations only) gassing can be tried. The second poison treatment should not be done less than a fortnight after the first. Regular maintenance of inspection and control must be kept up.

PRECAUTIONS

(1) All these rat poisons are dangerous if swallowed or taken into the mouth and they must be handled carefully.

(2) Containers for mixing bait must be thoroughly washed after use and the operators must also wash their hands.

(3) Supplies of poison must be kept in a locked store.

(4) Stale or residual poison bait must be collected and destroyed, *e.g.*, by burning.

(5) Moist baits containing zinc phosphide give off small amounts of phosphine gas which is easily detected by its strong-smell. This does not deter rats. Prolonged exposure to this gas may give rise to cumulative poisoning so mixing of zinc phosphide baits should be done only in well ventilated premises or out of doors. For this reason I prefer the dry grain mixture with a trace of vegetable oil.

Maintenance of Control

Whatever method is used it is essential to maintain the effort because spasmodic activity will be useless as a practical method of control. A careful survey of the premises and surrounding area should be made for signs of rats at intervals of not more than one month. This should be part of the routine inspection. Do not underrate the rat or you will be defeated. A permanent solution of the problem necessitates carefully planned operations throughout the area and co-operation of all parties.